

INTERNATIONAL STANDARD



**Safety of machinery – Electrical equipment of machines –
Part 32: Requirements for hoisting machines**



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**Safety of machinery – Electrical equipment of machines –
Part 32: Requirements for hoisting machines**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**SAFETY OF MACHINERY –
ELECTRICAL EQUIPMENT OF MACHINES –****Part 32: Requirements for hoisting machines****FOREWORD**

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This commented version (CMV) of the official standard IEC 60204-32:2023 edition 3.0 allows the user to identify the changes made to the previous IEC 60204-32:2008 edition 2.0. Furthermore, comments from IEC TC 44 experts are provided to explain the reasons of the most relevant changes, or to clarify any part of the content.

A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text. Experts' comments are identified by a blue-background number. Mouse over a number to display a pop-up note with the comment.

This publication contains the CMV and the official standard. The full list of comments is available at the end of the CMV.

IEC 60204-32 has been prepared by IEC technical committee 44: Safety of machinery – Electrotechnical aspects. It is an International Standard.

This third edition cancels and replaces the second edition published in 2008. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) alignment to the IEC 60204-1 sixth edition (2016) especially for:
 - requirements for earthing and bonding;
 - requirements for circuit protection;
 - consideration of use of Power Drive Systems;
 - protective bonding requirements and terminology;
 - requirements pertaining to safe torque off for PDS, emergency stop, and control circuit protection;
 - symbols for actuators of control devices;
- b) reference for high voltage electrical equipment;
- c) cableless control system requirements;
- d) EMC requirements;
- e) technical documentation requirements;
- f) general updating to current special national conditions, normative standards, and bibliographical references.

The text of this International Standard is based on the following documents:

Draft	Report on voting
44/1000/FDIS	44/1005/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

The following differing practices of a less permanent nature exist in the countries indicated below:

- 4.3.1: The voltage characteristics of electricity supplied by public distribution systems in Europe are given in EN 50160:2010.
- 5.1: Exception is not allowed (USA).
- 5.1: TN-C systems are not permitted in low-voltage installations in buildings (Norway).
- 5.2: Terminals for the connection of the protective earthing conductors may be identified by the colour green, the letters “G” or “GR” or “GRD” or “GND”, or the word “ground” or “grounding”, or with the graphical symbol IEC 60417-519:2002-10 or any combination (USA).
- 5.3.1: Isolation of the neutral conductor is mandatory in TN-systems (Norway).

6.3.3 b),

13.4.5 b),

18.2.1: TT power systems are not allowed (USA).

6.3.3,

18.2,

Annex A: TN systems are not used. TT systems are the national standard (Japan)

6.3.3 b) The use of residual current protective devices with a rated residual operating current not exceeding 1 A is mandatory in TT systems as a means for fault protection by automatic disconnection of supply (Italy).

7.2.3: Disconnection of the neutral conductor is mandatory in a TN-S system (France).

7.2.3: Third paragraph: distribution of a neutral conductor with an IT system is not allowed (USA and Norway).

7.10: For evaluation of short circuit ratings, the requirements of UL 508A Supplement SB may be used (USA).

8.2.2: See IEC 60364-5-54:2011, Annex E List of notes concerning certain countries. Maximum nominal AC control circuit voltage is 120 V (USA).

9.1.2: Only stranded wires are allowed on machines, except for 0,2 mm² solid conductors within enclosures (USA).

12.2: The smallest power circuit conductor allowed on machines is 0,82 mm² (AWG 18).

Table 5: Cross-sectional area is specified in NFPA 79 using American Wire Gauge (AWG) (USA). See Annex F.

13.2.2: For the protective conductor, the colour identification GREEN (with or without YELLOW stripes) is used as equivalent to the bicolour combination GREEN-AND YELLOW (USA and Canada).

13.2.3: The colour identification WHITE or GREY is used for earthed neutral conductors instead of the colour identification BLUE (USA and Canada).

15.2.2: First paragraph: Maximum value between conductors 150 V (USA).

15.2.2: Second paragraph, fifth bullet: The full load current rating of lighting circuits does not exceed 15 A (USA).

16.4: Nameplate marking requirements (USA).

A.2.2.2: The permissible maximum value of R_A is regulated (e.g. when $U_0 > 300$ V, R_A shall be less than 10 Ω , when $U_0 < 300$ V, R_A shall be less than 100 Ω , U_0 is the nominal AC line to earth voltage in volts (V) (Japan).

A.2.2.2: The maximum permissible value of R_A is 83 Ω (Netherlands).

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

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

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

It is important that high performance is not ~~to be~~ obtained at the expense of the essential factors mentioned above.

Figure 1 and Figure 2 have been provided as an aid to understanding the interrelationship of the various elements of a hoisting machine and its associated equipment. Figure 1 is an overall block diagram of a typical material handling system (a group of cranes working together in a coordinated manner) and Figure 2 is a block diagram of a typical crane and associated equipment showing the various elements of the electrical equipment addressed in this document.

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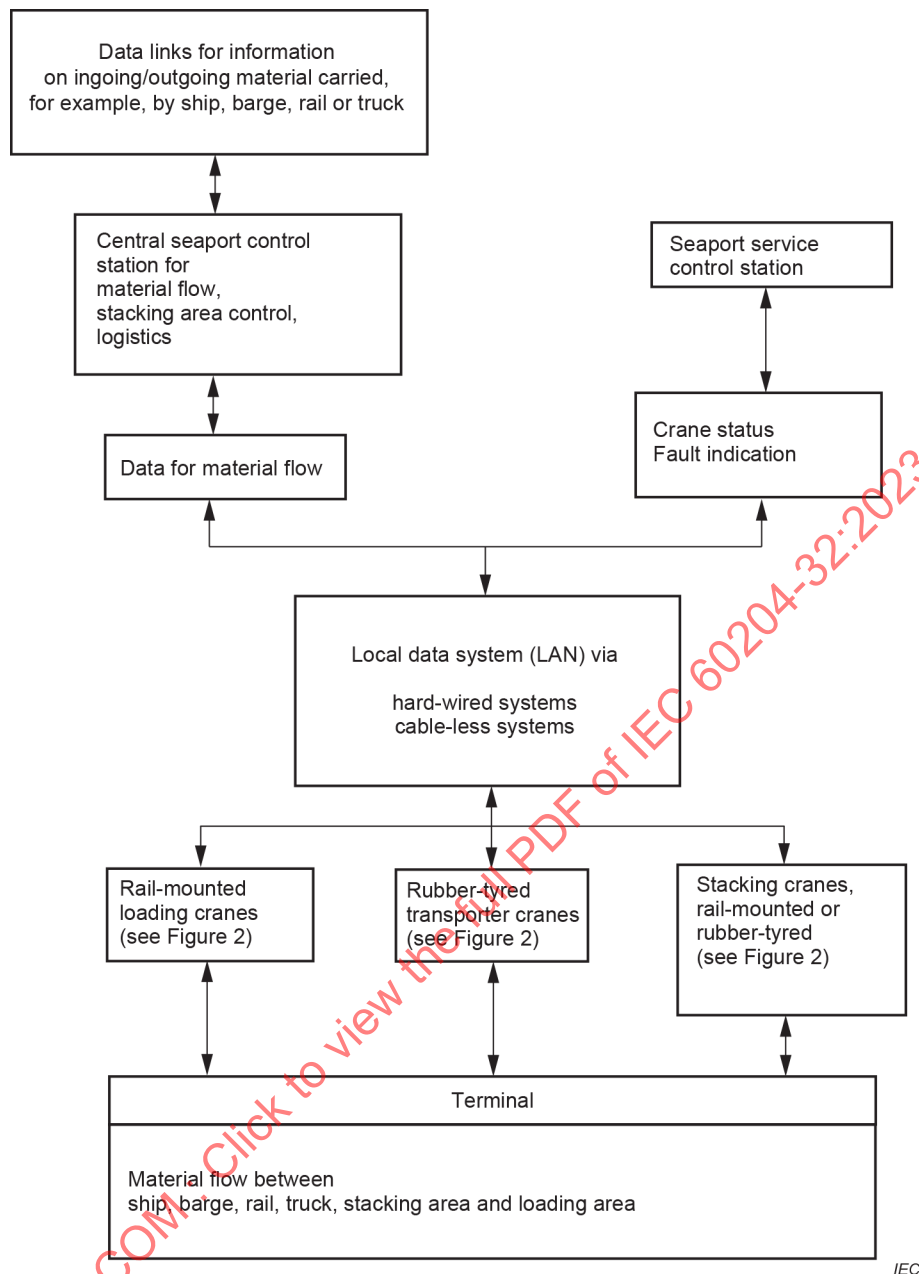
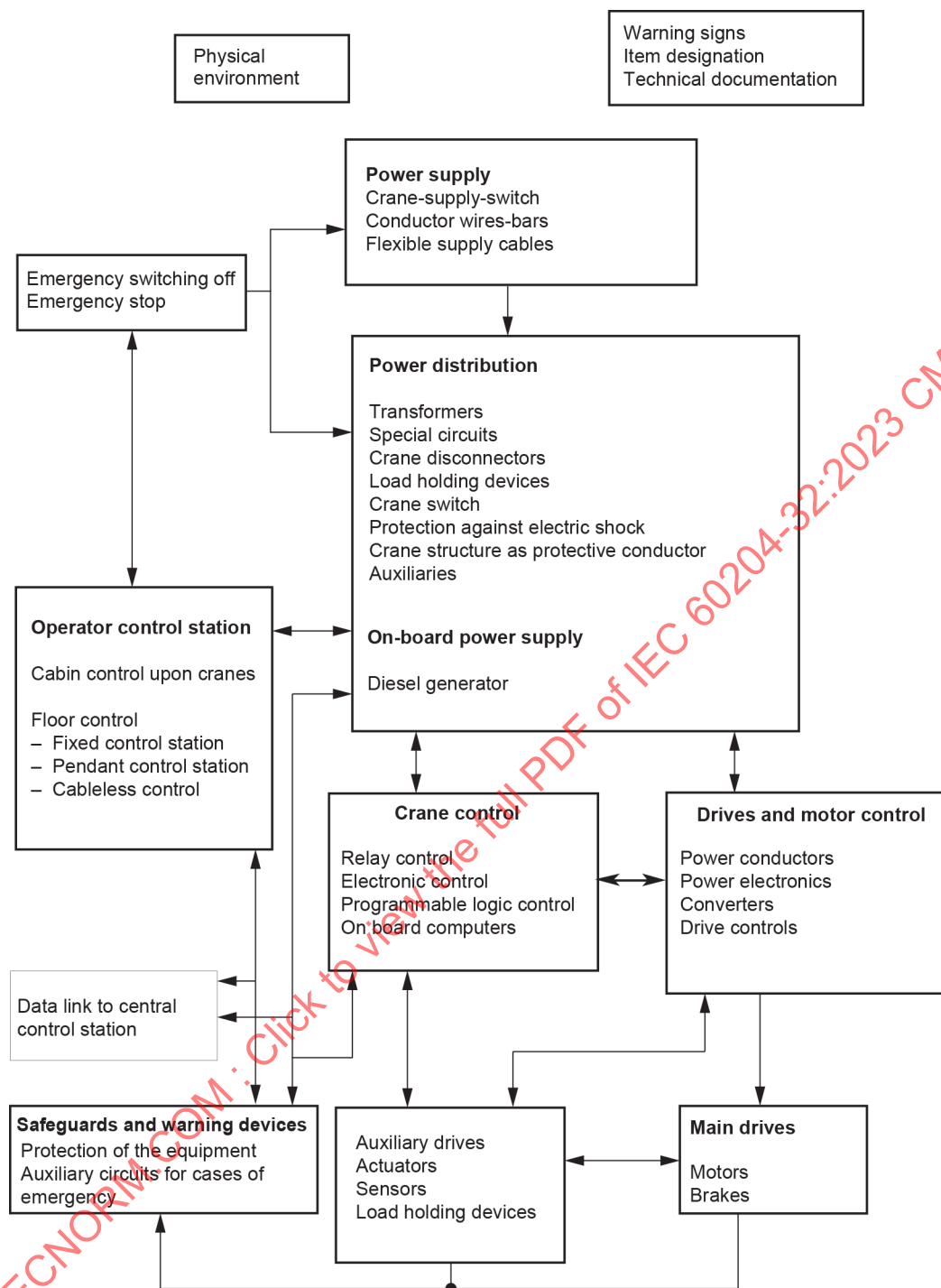


Figure 1 – Block diagram of combined working cranes in a typical material handling system in a seaport



IEC

Figure 2 – Block diagram of a typical crane and its associated electrical equipment

SAFETY OF MACHINERY – ELECTRICAL EQUIPMENT OF MACHINES –

Part 32: Requirements for hoisting machines

1 Scope

This part of IEC 60204 applies to ~~the application of electrical and~~, electronic, programmable **1** electronic equipment and systems to hoisting machines and related equipment, including a group of hoisting machines working together in a co-ordinated manner **2**.

NOTE 1 In this document, the term “electrical” includes both electrical and electronic matters (i.e. “electrical equipment” means both the electrical, electronic and programmable electronic equipment).

NOTE 2 In the context of this document, the term “person” refers to any individual and includes those persons who are assigned and instructed by the user or user’s agent(s) in the use and care of the hoisting machine in question.

The equipment covered by this document commences at the point of connection of the supply to the electrical equipment of the hoisting machine (crane-supply-switch) and includes systems for power supply and control feeders situated outside of the hoisting machine, for example, flexible cables or conductor wires or conductor bars (see Figure 3).

NOTE 3 ~~For the requirements for the electrical supply installation in buildings, see IEC 60364.~~ The requirements for the electrical supply installation of electrical equipment of a hoisting machine are given in IEC 60364.

This document is applicable to equipment or parts of equipment not exceeding 1 000 V AC or 1 500 V DC between lines and with nominal frequencies not exceeding 200 Hz.

NOTE 4 ~~For higher voltages, see IEC 60204-11.~~ Special requirements for electrical equipment of hoisting machines intended to be operated at higher voltages can be found in IEC 60204-11. **3**

This document 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 hoisting machine has unique requirements to be accommodated to provide adequate safety. This document does not cover noise risks.

Additional and special requirements can apply to the electrical equipment of hoisting machines including those that

- ~~— are intended for use in open air (i.e., outside buildings or other protective structures);~~
- handle or transport potentially explosive material (e.g. paint or sawdust);
- are intended for use in potentially explosive and/or flammable atmospheres;
- have special risks when transporting or moving certain materials;
- are intended for use in mines.

For the purposes of this document, hoisting machines include cranes of all types, winches of all types and storage and retrieval machines. The following product groups are included:

- overhead travelling cranes;
- mobile cranes;
- tower cranes;
- slewing luffing cranes;
- gantry cranes;

- offshore cranes;
- floating cranes;
- winches of all types;
- hoists and accessories;
- loader cranes;
- cable cranes;
- load holding devices;
- storage and retrieval machines;
- monorail hoists;
- straddle carriers;
- rubber tyred gantry cranes (RTGs).

NOTE 5 A definition of the different crane types can be found in ISO 4306-1.

This document does not cover individual items of electrical equipment other than their selection for use and their erection.

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.

IEC 60034-1:2017, *Rotating electrical machines – Part 1: Rating and performance*

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

IEC 60034-11, *Rotating electrical machines – Part 11: Thermal protection*

IEC 60068-2-27:1987/2008, *Basic Environmental testing procedures – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60068-2-31:2008, *Environmental testing – Part 2-31: Tests – Test Ec: Rough handling shocks, primarily for equipment-type specimens*

~~IEC 60068-2-32:1975, Basic environmental testing procedures – Part 2-32: Tests – Test Ed: Free fall
Amendment 2 (1990)~~

IEC 60072-1, *Rotating electrical machines – Dimensions and output series – Part 1: Frame numbers 56 to 400 and flange numbers 55 to 1080*

IEC 60072-2, *Dimensions and output series for rotating electrical machines – Part 2: Frame numbers 355 to 1000 and flange numbers 1180 to 2360*

IEC 60072-3, *Dimensions and output series for rotating electrical machines – Part 3: Small built-in motors – Flange numbers BF10 to BF50*

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

IEC 60309-1, *Plugs, fixed or portable socket-outlets and ~~couplers~~ appliance inlets for industrial purposes – Part 1: General requirements*

~~IEC 60332 (all parts), Tests on electric and optical fibre cables under fire conditions~~

IEC 60364-1:2005, *Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions*

IEC 60364-4-41:2005, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*
IEC 60364-4-41:2005/AMD1:2017

~~IEC 60364-4-42:2001, Electrical installations of buildings – Part 4-42: Protection for safety – Protection against thermal effects~~

IEC 60364-4-43:2001/2008, *Low-voltage electrical installations ~~of buildings~~ – Part 4-43: Protection for safety – Protection against overcurrent*

IEC 60364-5-52:2001/2009, *Low-voltage electrical installations ~~of buildings~~ – Part 5-52: Selection and erection of electrical equipment – Wiring systems*

IEC 60364-5-53:2002/2019, *Low-voltage electrical installations ~~of buildings~~ – Part 5-53: Selection and erection of electrical equipment – Devices for protection for safety, isolation, switching, control and monitoring*

IEC 60364-5-54:2002/2011, *Low-voltage electrical installations ~~of buildings~~ – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, ~~protective conductors~~ and protective ~~bonding~~ conductors*

IEC 60364-6:2006/2016, *Low-voltage electrical installations – Part 6: Verification*

IEC 60417, *Graphical symbols for use on equipment* (available at <https://www.graphical-symbols.info/equipment>)

~~IEC 60439-1:1999, Low-voltage switchgear and controlgear assemblies – Part 1: Type tested and partially type tested assemblies⁴. Amendment 1 (2004)~~

IEC 60445:2021, *Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors*

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

IEC 60447:2004, *Basic and safety principles for man-machine interface, marking and identification – Actuating principles*

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

~~IEC 60617, Graphical symbols for diagrams~~

⁴ ~~There exists a consolidated edition 4.1 (2004) that includes edition 4 and its amendment.~~

IEC 60664-1:~~2007~~, *Insulation coordination for equipment within low-voltage supply systems – Part 1: Principles, requirements and tests*

IEC 60755:2017, *General safety requirements for residual current operated protective devices*

~~IEC 60898 (all parts), Electrical accessories – Circuit breakers for overcurrent protection for household and similar installations~~

IEC 60947-1:~~2007~~, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 60947-2:~~2006~~2016, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*

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

IEC 60947-4-1:~~2000~~2018, *Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters*

~~Amendment 1 (2002)⁴~~

IEC 60947-5-1:~~2003~~2016, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

IEC 60947-5-5, *Low-voltage switchgear and controlgear – Part 5-5: Control circuit devices and switching elements – Electrical emergency stop device with mechanical latching function*

IEC 60947-6-2, *Low-voltage switchgear and controlgear – Part 6-2: Multiple function equipment – Control and protective switching devices (or equipment) (CPS)*

~~IEC 61082-1:2006, Preparation of documents used in electrotechnology – Part 1: Rules~~

IEC 61140, *Protection against electric shock – Common aspects for installations and equipment*

~~IEC 61180-2:1994, High-voltage techniques for low-voltage equipment – Part 2: Test equipment~~

IEC 61204-7, *Low-voltage switch mode power supplies – Part 7: Safety requirements*

IEC 61310 (all parts), *Safety of machinery – Indication, marking and actuation*

~~IEC 61346 (all parts), Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations~~

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

IEC 61557-3, *Electrical safety in low voltage distribution systems up to 1 000 V AC and 1 500 V DC – Equipment for testing, measuring or monitoring of protective measures – Part 3: Loop impedance*

IEC 61557-9:2014, *Electrical safety in low voltage distribution systems up to 1 000 V AC and 1 500 V DC – Equipment for testing, measuring or monitoring of protective measures – Part 9: Equipment for insulation fault detection in IT systems*

⁴ ~~There exists a consolidated edition 2.1 (2002) that includes edition 2 and its amendment.~~

IEC 61558-1, *Safety of ~~power transformers, power supplies, reactors and similar products~~ transformers, reactors, power supply units and combinations thereof – Part 1: General requirements and tests*

IEC 61558-2-2, *Safety of power transformers, power supplies, reactors and combinations thereof – Part 2-2: Particular requirements and tests for control transformers and power supply units incorporating control transformers*

IEC 61558-2-6, *Safety of ~~power transformers, power supply units and similar~~ transformers, reactors, power supply units and combinations thereof – Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers for general-use applications*

IEC 61558-2-16, *Safety of transformers, reactors, power supply units and combinations thereof – Part 2-16: Particular requirements and tests for switch mode power supply units and transformers for switch mode power supply units for general applications*

IEC 61800-3, *Adjustable speed electrical power drive systems – Part 3: EMC requirements and specific test methods for PDS and machine tools*

IEC 61800-5-1, *Adjustable speed electrical power drive systems – Part 5-1: Safety requirements – Electrical, thermal and energy*

IEC 61800-5-2:2007, *Adjustable speed electrical power drive systems – Part 5-2: Safety requirements – Functional*

IEC 61984, *Connectors – Safety requirements and tests*

IEC 62023, *Structuring of technical information and documentation*

~~IEC 62027, Preparation of parts lists~~

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

~~IEC 62079, Preparation of instructions – Structuring, content and presentation~~

IEC 62745:2017, *Safety of machinery – Requirements for cableless control systems of machinery*

~~ISO 7000:2004, Graphical symbols for use on equipment – Index and synopsis~~

ISO 7010, *Graphical symbols – Safety colours and safety signs – Registered safety signs, available at <https://www.iso.org/obp>*

ISO 12100:2010, *Safety of machinery – General principles for design – Risk assessment and risk reduction*

~~ISO 12100-1: Safety of machinery – Part 1: Basic terminology, methodology~~

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

ISO 13849-1:2006, *Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design*

ISO 13849-2:2003, *Safety of machinery – Safety-related parts of control systems – Part 2: Validation*

ISO 13850:2006/2015, *Safety of machinery – Emergency stop function – Principles for design*

~~ISO 13851:2002, *Safety of machinery – Two hand control devices – Functional aspects and design principles*~~

~~ISO 13852:1996, *Safety of machinery – Safety distances to prevent danger zones being reached by the upper limbs*~~

ISO 13857, *Safety of machinery – Safety distances to prevent hazard zones being reached by upper and lower limbs*

3 Terms, definitions and abbreviated terms 4

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions 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>

3.1.1

actuator

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

Note 1 to entry: The actuator may take the form of a handle, knob, push-button, roller, plunger, etc.

Note 2 to entry: There are some actuating means that do not require an external actuating force but only an action, for example, touchscreens.

~~NOTE 3 – Note the difference between actuator and machine actuator (3.44).~~

Note 3 to entry: See also 3.1.53.

3.1.2

ambient temperature

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

3.1.3

apparatus

finished device or combination thereof made commercially available as a single functional unit, intended for the end user and liable to generate electromagnetic disturbance, or the performance of which is liable to be affected by such disturbance

3.1.4

~~(electrically) protective barrier~~

part providing protection against ~~direct~~ contact by a human being or livestock with hazardous-live parts from any usual direction of access

~~[IEV 826-12-23]~~

[SOURCE: IEC 60050-195:2021, 195-06-15, modified – The term "protective barrier" has been replaced with "barrier".]

3.1.5**basic drive module****BDM**

electronic power converter and related control, connected between an electric supply and a motor

[SOURCE: IEC 61800-2:2021, 3.4]

3.1.6**basic protection**

protection against electric shock under fault-free conditions

Note 1 to entry: Previously referred to as “protection against direct contact”

[SOURCE: IEC 60050-195:1998, 195-06-01, modified – The note to entry has been added.]

3.1.7**cabin-controlled hoisting machine**

hoisting machine operated from a cabin permanently attached to the hoisting machine

3.1.8**cable tray**

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

Note 1 to entry: A cable tray ~~may~~ can be perforated or mesh.

[SOURCE: IEC 60050-826:2022, 826-15-08]

3.1.9**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/or for the accommodation of other electrical equipment including information technology equipment

[SOURCE: IEC 60050-826:2022, 826-15-04]

3.1.10**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)~~

<two or more control devices> existing in an actuated condition at the same time, but not necessarily synchronously

3.1.11**conductor wire****conductor bar****conductor rail**

wire, conductive bar or rail of a feeder system having a sliding current collector

3.1.12**conduit**

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

Note 1 to entry: Conduits should be sufficiently ~~closed~~ close-jointed so that the insulated conductors and/or cables can only be drawn in and not inserted laterally.

[SOURCE: IEC 60050-826:2022, 826-15-03]

3.1.13

control circuit

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

3.1.14

control device

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

3.1.15

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

[SOURCE: IEC 60050-441:1984, 441-11-03, ~~modified~~]

3.1.16

control station

operator control station

assembly of one or more control actuators fixed on the same panel or located in the same enclosure

Note 1 to entry: A control station may also contain related equipment, for example, potentiometers, signal lamps, instruments, display devices, etc.

Note 2 to entry: A definition of "actuator" is given in 3.1.1.

3.1.17

controlled stop

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

3.1.18

crane

machine for hoisting/lowering and horizontally relocating suspended loads

3.1.19

crane-disconnector

~~hand-operated~~ disconnecting device installed on a hoisting machine for disconnecting (isolating) a supply circuit (e.g. for repair or maintenance work)

3.1.20

crane-supply-switch

disconnecting (isolating) and switching device used to disconnect the hoisting machine from the incoming supply

3.1.21

crane-switch

switching device designed to break the electrical power supply to the connected drives (e.g. for use in cases of emergency stop)

3.1.22**(continuous) current-carrying capacity**

ampacity (US)

maximum value of electric current which can be carried continuously by a conductor, a device or an apparatus, under specified conditions without its steady-state temperature exceeding a specified value

[SOURCE: IEC 60050-826:2022, 826-11-13]

3.1.23**direct contact**

electric contact of ~~persons~~ human beings or ~~animals~~ livestock with live parts

~~[IEV 826-12-03]~~

[SOURCE: IEC 60050-195:2021, 195-06-03.]

3.1.24**direct opening action**

<contact element> 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)

[SOURCE: IEC 60947-5-1:2016, K.2.2]

3.1.25**disconnecting device**

device which provides, in the open position, an isolating distance in accordance with specified requirements

3.1.26**duct**

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

Note 1 to entry: Conduits (3.1.12), cable trunking systems (3.1.9) and underfloor channels are types of duct.

3.1.27**earth****local earth****ground (US)****local ground (US)**

part of the Earth which is in electric contact with an earth electrode and that has an electric potential not necessarily equal to zero

[SOURCE: IEC 60050-195:2021, 195-01-03, modified – The terms "earth" and "ground" have been added.]

3.1.28**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

3.1.29**electronic equipment**

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

3.1.30

emergency stop device

manually actuated control device used to initiate an emergency stop function

[SOURCE: ISO 13850:2015, 3. 3]

~~NOTE—See Annex E.~~

3.1.31

emergency switching-off device

manually actuated control device used to switch off or to initiate the switching off of 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 Annex E.~~

3.1.32

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~~ use of a key or tool to open a door or ~~the removal of~~ remove a barrier ~~by the use of a key or tool~~, and which is clearly marked by appropriate warning signs

3.1.33

enclosure

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

Note 1 to entry: The definition taken from the existing IEC needs the following explanations within the scope of this document.

- 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 hoisting machine or separate from the hoisting machine;
 - a compartment consisting of an enclosed space within the hoisting machine structure (e.g. box girder).

3.1.34

electrical equipment

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

items used in connection with the utilisation of electricity by machines or parts of machines, for example material, fittings, devices, components, appliances, fixtures, apparatus, and similar

3.1.35

equipotential bonding

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

set of electric connections intended to achieve equipotentiality between conductive parts

[SOURCE: IEC 60050-195:2021, 195-01-10]

3.1.36

exposed conductive part

conductive part of ~~electrical~~ equipment that can be touched and that is not ~~normally~~ live under normal conditions, but that can become live ~~under fault conditions~~ when basic insulation fails

~~[IEV 826-12-10, modified]~~

[SOURCE: IEC 60050-195:2021, 195-06-10]

3.1.37

extraneous conductive part

conductive part not forming part of the electrical installation and ~~liable~~ that is likely to introduce an electric potential, generally the ~~earth~~ electric potential of a local earth

~~[IEV 826-12-11]~~

[SOURCE: IEC 60050-195:2021, 195-06-11]

3.1.38

failure

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

Note 1 to entry: After the failure, the item ~~has a~~ is in fault condition.

Note 2 to entry: A failure is an event, as distinguished from a fault, which is a state.

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

Note 4 to entry: In practice the terms “fault” and “failure” are often used synonymously.

~~[IEV 191-04-01]~~

[SOURCE: IEC 60050-845:2020, 845-27-105, modified – A fourth note to entry has been added.]

3.1.39

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 to entry: 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 IEC 60050-195-01. 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.~~

3.1.40

fault protection

protection against electric shock under single-fault conditions

Note 1 to entry: Previously referred to as “protection against indirect contact”.

[SOURCE: IEC 60050-195:2021, 195-06-02, modified – A note to entry has been added.]

3.1.41

first environment

environment that includes domestic premises, it also includes establishments directly connected without intermediate transformers to a low-voltage power supply network which supplies buildings used for domestic purposes

Note 1 to entry: Houses, apartments, commercial premises or offices in a residential building are examples of first environment locations.

3.1.42

fixed installation

particular combination of several types of apparatus and, where applicable, other devices, which are assembled, installed and intended to be used permanently at a predefined location

3.1.43

functional bonding

equipotential bonding necessary for proper functioning of electrical equipment

3.1.44

guard

part of a hoisting 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 12100-1, 3.25, modified]~~

3.1.45

hand-held direct-control device

manually operated switching device, the enclosure of which is portable by hand during operation, acting direct on a power circuit **without a control circuit**

3.1.46

hazard

potential source of ~~physical injury or damage to health~~ **harm**

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, fire hazard).

Note 2 to entry: The hazard envisaged by this definition either

- is permanently present during the intended use of the machine (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 – **Note 3 has been deleted.**]

3.1.47

indirect contact

electric contact of ~~persons~~ **human beings** or ~~animals~~ **livestock** with exposed conductive parts that have become live under fault conditions

~~[IEV 826-12-04]~~

[SOURCE: IEC 60050-195:2021, 195-06-04]

3.1.48

inductive power supply system

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

Note 1 to entry: The track conductor and the pick-up are analogous to the primary and secondary of a transformer, respectively.

3.1.49

instructed person

~~(electrically)~~ **instructed person**

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

~~[IEV 826-18-02]~~

[SOURCE: IEC 60050-195:2021, 195-04-02]

3.1.50**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 hoisting machine~~

arrangement of devices operating together to

- prevent hazardous situations,
- prevent damage to equipment or material,
- prevent specified operations,
- ensure correct operations

3.1.51**limiting device**

device which prevents a hoisting machine or a hoisting machine element from exceeding a designed limit (e.g. space limit, pressure limit, load limit, load moment limit)

~~[ISO 12100-1, 3.26.8]~~

[SOURCE: ISO 12100 3.28.8, modified – In the definition, "machine or hazardous machine condition(s)" has been replaced by "hoisting machine or a hoisting machine element" and "load limit" has been added.]

3.1.52**live part**

~~conductor or conductive part intended to be energized in normal operation, including a neutral conductor, but by convention, not a PEN conductor or PEM conductor or PEL conductor~~

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

~~[IEV 826-12-08]~~

conductive part intended to be energized under normal operating conditions, including the neutral conductor and mid-point conductor, but excluding the PEN conductor, PEM conductor and PEL conductor

[SOURCE: IEC 60050-195:2021, 195-02-19]

3.1.53**machine actuator**

power mechanism used to effect motion of the hoisting machine (for example, motor, solenoid, pneumatic or hydraulic cylinder)

3.1.54**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

Note 1 to entry: The term "machinery" also covers an assembly of machines which, in order to achieve the same ~~end~~ target, are arranged and controlled so that they function as an integral whole

Note 2 to entry: The term "component" is used here in a general sense and does not refer only to electrical components.

~~[ISO 12100-1, 3.1, modified]~~

3.1.55

manually controlled hoisting machine

hoisting machine with continuous ~~direct~~ manual control of the load and with the load continuously visible to the operator

3.1.56

marking

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

3.1.57

neutral conductor

N

conductor electrically connected to the neutral point and capable of contributing to the distribution of electrical energy

~~[IEV 826-14-07]~~

[SOURCE: IEC 60050-195:2021, 195-02-06]

3.1.58

obstacle

part preventing unintentional direct contact by a human being or livestock with live parts, but not preventing ~~direct~~ such contact by deliberate action

[SOURCE: IEC 60050-195:2021, 195-06-16, modified – The term "protective obstacle, <electrically>" has been replaced with "obstacle".]

3.1.59

overcurrent

electric current ~~exceeding the rated electric current~~ the values of which exceeds a specific limiting value

~~[IEV 826-11-14]~~

[SOURCE: IEC 60050-151:2001, 151-15-28]

3.1.60

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 1 to entry: "Overload" should not be used as a synonym for "overcurrent".

Note 2 to entry: In hoisting machines the term "overload" is also used for mechanical overload, which may or may not cause an electrical overload.

3.1.61

plug/socket combination

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

Note 1 to entry: Examples of plug/socket combination include

- connectors which ~~conform to~~ 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.

3.1.62**power circuit**

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

3.1.63**Power Drive System****PDS**

system consisting of one or more complete drive module(s) (CDM) and a motor or motors

[SOURCE: IEC 61800-2:2021, 3.52]

3.1.64**PDS of category 1**

PDS intended for use in the first environment

3.1.65**PDS of category 2**

PDS, which is neither a plug-in device nor a movable device and, when used in the first environment, is intended to be installed and commissioned only by a professional

Note 1 to entry: A professional is a person or an organization having necessary skills in installing and/or commissioning power drive systems, including their EMC aspects.

3.1.66**PDS of category 3**

PDS intended for use in the second environment and not intended for use in the first environment

3.1.67**PDS of category 4**

PDS of rated voltage equal to or above 1 000 V, or rated current equal to or above 400 A, or intended for use in complex systems in the second environment

3.1.68**protective bonding**

equipotential bonding for protection against electric shock

Note 1 to entry: Measures for protection against electric shock can also reduce the risk of burns or fire.

Note 2 to entry: Protective bonding can be achieved with protective conductors and protective bonding conductors and by conductive joining of conductive parts of the machine and its electrical equipment.

3.1.69**protective bonding circuit**

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

3.1.70**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 826-13-22, modified]~~

conductor providing a primary fault current path from the exposed conductive parts of the electrical equipment to a protective earthing (PE) terminal

3.1.71

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

3.1.72

reference designation

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

3.1.73

risk

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

Note 1 to entry: "Harm" refers to physical injury or damage to health.

~~[ISO 12100-1, 3.11, modified]~~

[SOURCE: ISO 12100:2010, 3.12, modified – Note 1 to entry has been added.]

3.1.74

safeguard

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

3.1.75

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

[SOURCE: ~~ISO 12100-1, 3.20~~ ISO 12100:2010, 3.21]

3.1.76

~~safety-related control function (safety-related control circuit)~~

~~control function (control circuit) of a hoisting machine that is intended to maintain the safe condition of the machine or prevent an immediate increase of the risk(s)~~

3.1.76

safety function

function of a machine whose failure can result in an immediate increase of the risk(s)

[SOURCE: ISO 12100:2010, 3.30]

3.1.77

second environment

environment that includes all establishments other than those directly connected to a low voltage power supply network which supplies buildings used for domestic purposes

Note 1 to entry: Industrial areas, technical areas of any building fed from a dedicated transformer are examples of second environment locations.

3.1.78

servicing level

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

3.1.79**short-circuit current**

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

[SOURCE: IEC 60050-441:1984, 441-11-07]

3.1.80**short-circuit current rating**

value of prospective short-circuit current that can be withstood by the electrical equipment for the total operating time (clearing time) of the short-circuit protective device (SCPD) under specified conditions

3.1.81**skilled person**~~{electrically}~~ **skilled person**

person with relevant **training**, education and experience to enable him or her to perceive risks and to avoid hazards that electricity can create

~~[IEV 826-18-01]~~

[SOURCE: IEC 60050-195:2021, 195-04-01, modified – Training is an additional and necessary condition.]

3.1.82**supplier**

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

Note 1 to entry: The user organization may also act in the capacity of a supplier to itself.

3.1.83**switching device**

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

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

[SOURCE: IEC 60050-441:1984, 441-14-01, modified – In the definition, "and/" has been added.]

3.1.84**terminal**

part of an equipment or a component to which a conductor is attached, providing a re-usable connection

[SOURCE: IEC 60050-442:1998, 442-06-05, modified – In the definition, "or a component" has been added.]

3.1.85**uncontrolled stop**

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

Note 1 to entry: This definition does not imply any particular state of other (e.g. non-electrical) stopping devices, for example, mechanical or hydraulic brakes that are outside the scope of this document.

3.1.86**user**

entity who utilizes the hoisting machine and its associated electrical equipment

3.2 Abbreviated terms **5**

AWG	American Wire Gauge
AC	Alternating Current
BDM	Basic Drive Module
CCS	Cableless Control System
DC	Direct Current
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference
PDS	Power Drive System
PELV	Protective Extra-Low Voltage
RCD	Residual Current protective Device
RMS	Root Mean Square
SCPD	Short-Circuit Protective Device
SELV	Safe Extra-Low Voltage
STO	Safe Torque Off

4 General requirements

4.1 General considerations

This document is intended to apply to electrical equipment used with a wide variety of hoisting machines and with a group of hoisting 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 hoisting machine. This will ~~determine the acceptable level of risk, and the necessary protective measures~~

- identify the need for risk reduction, and
- determine adequate risk reductions, and
- determine the necessary protective measures

for persons who can be exposed to those hazards, while still maintaining an ~~acceptable~~ appropriate level of performance of the hoisting 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 fire of electrical origin;
- failures or faults in control circuits (or components and devices associated with those circuits) resulting in the malfunctioning of the hoisting machine;
- disturbances or disruptions in power sources as well as failures or faults in the power circuits resulting in the malfunctioning of the hoisting machine;
- loss of continuity of circuits that can result in a failure of a safety function, for example those that depend on 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 hoisting machine;
- release of stored energy (either electrical or mechanical) resulting in, for example, electric shock, unexpected movement that can cause injury;
- acoustic noise and mechanical vibration at levels that cause health problems to persons;
- surface temperatures that can cause injury.

~~In accordance with the hierarchy of protective measures described in ISO 12100-1 and ISO 12100-2, the required risk reduction is achieved by measures implemented by the supplier at the design stage and further measures implemented by the user.~~

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

The design and development process shall identify hazards and the risks arising from them. Where the hazards cannot be removed and/or those 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, flashing beacons, warning notices or signs to raise ~~awareness~~ of the risks) shall be provided where further risk reduction is necessary. In addition, working procedures that reduce risk ~~may~~ can be necessary.

~~The use of the inquiry form as shown in Annex B of this standard is recommended to facilitate an agreement~~ It is recommended that, where the user is known, Annex B be used to facilitate an exchange of information 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 hoisting machine (or group of hoisting machines) and the application;
- facilitate maintenance and repair; and
- ~~advance~~ improve the reliability and ease of operation.

NOTE The use of Annex B ~~may~~ can also be useful to determine if a catalogued hoisting machine is suitable for the intended use.

4.2 Selection of equipment

4.2.1 General

Electrical components and devices shall:

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

4.2.2 Selection of power contactors

The contactors with their associated short-circuit protective devices shall have type "2" coordination in accordance with IEC 60947-4-1:2018, 8.2.5.1.

Contactors which perform the stopping function of motion drives, initiated by safety-related control circuits, shall be selected and arranged with other equipment in such a way that contact welding either will not occur or will not prevent the emergency stop function. The supplier's recommendations should be followed (see also 7.2.9).

~~NOTE Contactors directly controlling motions and demanding a great number of contactor operations should have a mechanical life of at least 3 million operating cycles~~ should have mechanical and electrical lifetime regarding requirements for application in use. **6**

4.2.3 ~~Electrical equipment in compliance with the IEC 60439 series~~

~~The electrical equipment of the hoisting machine shall conform to safety requirements identified by the risk assessment of the hoisting machine. Depending upon the hoisting machine, its intended use and its electrical equipment, the designer may select parts of the electrical equipment of the hoisting machine that comply with IEC 60439-1 and, as necessary, other relevant parts of the IEC 60439 series.~~

4.2.3 Switchgear

In addition to the requirements of this document, depending upon the hoisting machine, its intended use and its electrical equipment, the designer may select parts of the electrical equipment of the hoisting machine that conform to relevant parts of the IEC 61439 series.

4.2.4 Selection of PDS

For the PDSs or part of PDS, when it will be incorporated into electrical equipment of hoisting machines, IEC 61800-5-1 shall apply. **7**

4.3 Electrical supply

4.3.1 General requirements

The electrical equipment shall be designed to operate correctly with the conditions of the supply at the point of supply (i.e. at the crane-supply-switch, see Figure 3):

- 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 in 4.3.4~~ (see 4.3.4).

4.3.2 AC supplies

Voltage Steady-state voltage: 0,9 to 1,1 of nominal voltage

~~NOTE – For certain applications (for example, large container cranes) and by agreement with the user, the voltage range may be reduced to 0,95 ... 1,05 of the nominal voltage at the point of supply (i.e., at the crane supply switch; see Figure 3).~~

Frequency 0,99 to 1,01 of nominal frequency continuously;
0,98 to 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~~ 12 % of the total RMS voltage between live conductors for the sum of the second through to ~~fifth~~ the thirtieth harmonic. ~~An additional 2 % of the total r.m.s. voltage between live conductors for the sum of the sixth to 30th 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 shall exceed 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. There shall be more than 1 s between successive interruptions.

~~NOTE 1 – In some semiconductor converter drives with power feedback, voltage interruptions as short as 3 ms or less can cause conduction-through and fuse blowing.~~

~~NOTE 2 – The crane switch can operate very frequently. All the components (for example, charging circuitries) need to be selected to allow foreseen switching frequency including the use in commissioning phase.~~

Voltage dips Voltage dips shall not exceed 20 % of the ~~peak~~ RMS 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 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. There shall be more than 1 s between successive interruptions.

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

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

4.3.4 ~~On-board power supply~~ Special supply systems 8

For special supply systems (e.g. on-board generators, DC bus, etc.), 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.

~~For a.c. power supply systems, means shall be provided to switch off the power supply automatically when~~

~~— the supply voltage is not within 0,85 ... 1,1 of nominal voltage;~~

~~— the frequency is not within 0,95 ... 1,05 of nominal frequency.~~

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 hoisting machines covered by this document. When special conditions apply or the limits specified are exceeded, an ~~agreement~~ exchange of information between user and supplier (see 4.1) is recommended (see Annex B).

4.4.2 Electromagnetic compatibility (EMC)

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

For electrical equipment of hoisting machines including PDS or part of PDS, IEC 61800-3 shall be applied.

NOTE 1 The generic EMC standards IEC 61000-6-1 or IEC 61000-6-2 and IEC 61000-6-3 or IEC 61000-6-4 or IEC 61000-6-8 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~~ 9

- ~~— power supply filtering;~~
- ~~— cable shielding;~~
- ~~— enclosures designed to minimize r.f. radiation;~~
- ~~— r.f. suppression techniques.~~

~~Measures to enhance the immunity of the equipment against conducted and radiated r.f. 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 (2002-10);~~



- ~~— connection of the chassis to earth (PE) using a conductor with low r.f. impedance and as short as practicable;~~
- ~~— connection of sensitive electrical equipment or circuits direct to the PE circuit or to a functional earthing conductor (FE) (see Figure 4), to minimize common mode disturbance. This latter terminal should be marked or labelled by the symbol IEC 60417 5018 (2002-10);~~



- ~~— separation of sensitive circuits from disturbance sources;~~
- ~~— enclosures designed to minimize r.f. 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 r.f. impedance termination.~~~~

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~~ in ambient air temperatures outside of enclosures (cabinet or box) between 0 °C and +40 °C. For very hot environments (e.g. hot climates, steel mills, paper mills) and for cold environments, additional measures are recommended (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 are 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 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.

For equipment to be used at higher altitudes, it is necessary to take into account changes in parameters for example, the reduction of: **10**

- the dielectric strength; and
- the switching capability of the devices; and
- the cooling effect of the air.

Other parameters of different components can also alter with altitude. When the characteristic of a component can be altered by the altitude, an appropriate correction factor shall be applied according to the information of its manufacturer.

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 (e.g. dust, acids, corrosive gases, salts) that can be 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 is recommended 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 hoisting 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 sources of vibration, or by provision of anti-vibration mountings. ~~A special agreement is recommended 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 $-25\text{ }^{\circ}\text{C}$ to $+55\text{ }^{\circ}\text{C}$ and for periods not exceeding 24 h at up to $+70\text{ }^{\circ}\text{C}$. 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 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 hoisting machine for transport, or that is independent of the hoisting machine, shall be provided with suitable means for handling, ~~including where necessary means for handling~~ by cranes or similar equipment (see also 13.4.6).

4.7 Installation

Electrical equipment shall be installed in accordance with the electrical equipment supplier's instructions.

NOTE Annex C and Annex G give additional information.

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 hoisting 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 hoisting machine. For large complex hoisting machines, there may be a need for more than one incoming supply (see 5.3.5.1).

Unless a plug is provided with the hoisting machine for the connection to the supply (see 5.3.2 e)), it is recommended that the supply conductors are terminated at the crane-supply-switch. 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 hoisting 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)~~. The neutral terminal may be provided as part of the supply disconnecting device.

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 supply (see Figure 3) to the hoisting machine for TN-C systems provided they are in accordance with 12.7.2.

~~All~~ Terminals for the incoming supply connection shall be clearly identified in accordance with IEC 60445:2021. For the identification of the external protective conductor terminal, see 5.2.

5.2 Terminal for connection ~~to~~ of the external protective ~~earthing system~~ conductor

For each incoming supply, a terminal shall be provided in the ~~vicinity of~~ same compartment as the associated ~~phase line~~ conductor terminals (see 8.2.1) for connection of the hoisting machine to the external protective ~~conductor 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 determined in relation to the size of the associated line conductors in accordance with Table 1.

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

Cross-sectional area of ~~phase line~~ conductors ~~supplying the equipment~~ S mm ²	Minimum cross-sectional area of the ~~external~~ corresponding protective ~~copper~~ conductor S_p 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 and type 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 60445:2021).

5.3 Supply disconnecting and switching devices

5.3.1 General

The functions of supply disconnection and/or switching are performed by the following devices:

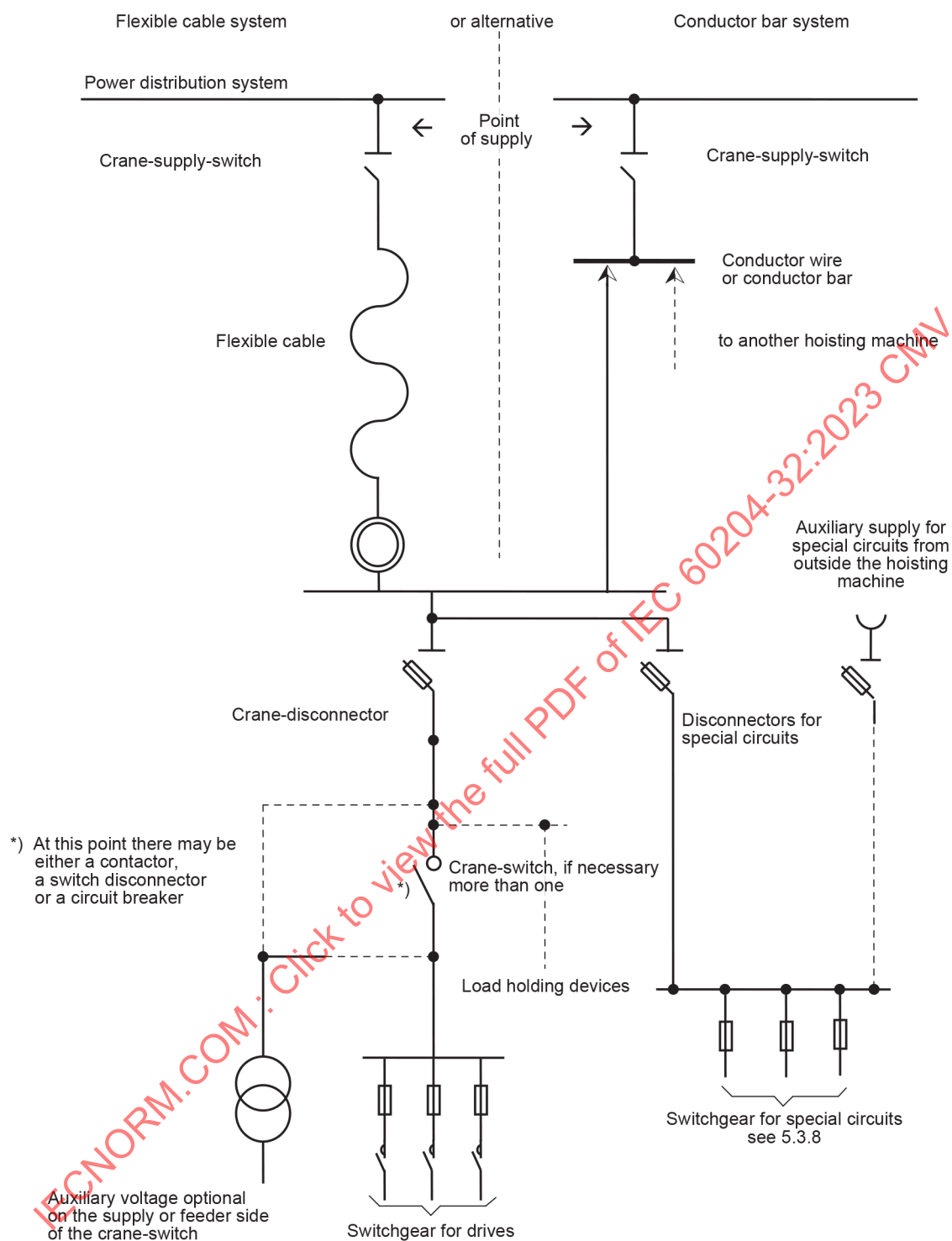
- crane-supply-switch (see 5.3.5);
- crane-disconnector (see 5.3.6);
- crane-switch (see 5.3.7).

See also Figure 3.

5.3.2 Type

The supply disconnecting and switching devices can 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 60947-2:2016;
- d) 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;
- e) a plug/socket combination for a flexible cable supply;
- f) control and protective switching device suitable for isolation, in accordance with IEC 60947-6-2.



IEC

Figure 3 – Examples of electrical supply systems

5.3.3 Requirements

When the supply disconnecting and switching 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 (2002-10) and IEC 60417-5007 (2002-10), 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 (e.g. 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 (e.g. 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 ~~for~~ other loads. The calculated breaking capacity may be reduced by the use of a proven ~~simultaneity~~ diversity factor. Where motor(s) are supplied by converter(s) or similar devices, the calculation should take into account the possible effect on the required breaking capacity.

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

- Have the ~~switching~~ breaking 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 ~~for~~ other loads. The calculated breaking capacity may be reduced by the use of a proven diversity factor. When the interlocked switching device is electrically operated (e.g. a contactor), it shall have an appropriate utilization category. Where motor(s) are supplied by converter(s) or similar devices, the calculation should take into account the possible effect on the required breaking capacity.
- Fulfil the requirements 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 utilization 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 of the supply disconnecting device 11

The operating means (e.g. a handle) of the supply disconnecting and switching device shall be external to the enclosure of the electrical equipment.

Exception: power-operated switchgear need not be provided with a handle outside the enclosure where other means (e.g. pushbuttons) are provided to open the supply disconnecting device from outside the enclosure.

The operating means ~~(for example, a handle)~~ of the supply disconnecting device and switching 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 Further information about direction of operation is available in IEC 61310-3.

Where the external operating means is not intended for emergency operations:

- it is recommended that it be coloured BLACK or GREY (see 10.2);
- a supplementary cover or door that can be readily opened without the use of a key or tool may be provided, for example for protection against environmental conditions or mechanical damage. Such a cover/door shall clearly show that it provides access to the operating

means. This can be achieved, for example, by use of the relevant symbol IEC 60417-6169-1 (2012-08) (Figure 4) or IEC 60417-6169-2 (2012-08), (Figure 5).

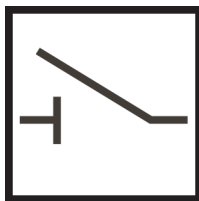


Figure 4 – Disconnector isolator

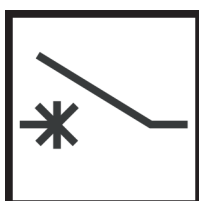


Figure 5 – Disconnecting circuit breaker

5.3.5 Crane-supply-switch

5.3.5.1 General

NOTE The following 5.3.5.1 to 5.3.5.3 do not apply to hoisting machines having on-board power supplies and without an alternative power supply from the outside.

Crane-supply-switches shall be provided

- for disconnecting (isolating) the conductor wires or conductor bars or cables to which the hoisting machine(s) is connected from the incoming supply for repair and maintenance works (e.g. on the conductor wires to the hoisting machine(s)); and
- where required for emergency stop and/or emergency switching-off (see 9.2.5.4).

Where two or more incoming supplies are used, a crane-supply-switch shall be provided for each supply, together with protective interlocks to ensure their correct operation.

The requirements of 5.6 shall apply as appropriate to crane-supply-switches.

5.3.5.2 Type

The crane-supply-switch shall be one of the types specified in 5.3.2.

In the case of hoisting machines ~~used at~~ on construction sites, equipment on the site distribution board may be used to achieve the function of the crane-supply-switch. The requirement of 5.6 shall be fulfilled by locking regardless of whether or not the disconnecting means is under immediate supervision.

5.3.5.3 Requirements

In the case of a single hoisting machine, the breaking capacity shall be sufficient to switch off the sum of the current under stalled rotor condition of the largest drive and the normal running currents of the other drives that can be operating at the same time.

NOTE If there is more than one hoisting machine on one common power supply according to the given service conditions, a proven simultaneity factor ~~may~~ can be used.

If the crane-supply-switch performs the emergency switching-off function according to 9.2.5.4.3, it shall be capable of being opened (remotely or directly) from an easily accessible place(s) close to the hoisting machine.

The reconnection of a crane-supply-switch that has been remotely operated by an emergency switching-off device shall only be possible after the resetting of the emergency switching-off device(s).

Where a conductor wire or conductor bar is fed by several crane-supply-switches connected in parallel, they shall be provided with protective interlocks to ensure their correct operation.

It is recommended that the crane-supply-switch used to energize an unprotected conductor wire, or conductor bar, or a remote control for the crane-supply-switch be so located that as much as possible of the conductor wire or conductor bar is visible from that place of operation.

The above requirements ~~shall~~ **should** also apply in special cases, for example, where

- there are two main supply conductor wires or conductor bars or conductor systems, either of which may be used for supplying the hoisting machine(s); or
- a main supply conductor wire or conductor bar is divided into isolated sections.

In cases where these requirements cannot be fulfilled, the necessary safety shall be provided by other measures.

5.3.6 Crane-disconnector

5.3.6.1 General

A hoisting machine shall be equipped with a single crane-disconnector to enable the electrical equipment to be isolated for maintenance and repair purposes, and to prevent unexpected start-up during mechanical work on the hoisting machine, except under the following circumstances.

- A crane-disconnector is not required if there are no connections and branches in the wiring system between the intended crane-disconnector position and the crane-switch specified in 5.3.7, and the crane-switch performs the functions of the crane-disconnector and conforms to the requirements of 5.6.
- A crane-disconnector is not required for a single hoisting machine which is floor-controlled, and where the crane-supply-switch performs this function.

NOTE A floor-controlled hoisting machine is operated from a suspended pendant control station, a remote fixed control station, or a portable control station.

- A crane-disconnector is not necessary in cases where the voltage can be reduced to, and maintained at, zero by other means (e.g. locking off a diesel generator fuel supply or starter mechanism, etc.).
- On hoisting machines with power supplied at voltages of more than 1 kV AC and having one or more transformers installed on the hoisting machine, supplying a low-voltage system, one or more crane-disconnectors may be required on the secondary side of each transformer to isolate the low-voltage sections (see also 5.5). Circuits associated with each crane-disconnector shall be clearly identifiable, for example, by
 - separation, or
 - barriers, or
 - marking and labelling.

NOTE Preference should be given to the disconnection of a hoisting machine using only one crane-disconnector.

5.3.6.2 Type

Where provisions are made against both inadvertent and unauthorized opening, the crane-disconnector shall, as a minimum, conform to the requirements for disconnectors given in IEC 60947-3. Otherwise, it shall meet the requirements for switch-disconnectors given in IEC 60947-3. The actuator of the crane-disconnector shall conform to the requirements of 5.3.4.

Removable collectors or plug/socket combinations may be used as crane-disconnectors when they perform the same function.

On hoisting machines with an alternative power-supply system, the changeover switch of the supplies may be used as a crane-disconnector if it has a neutral off-position and meets the requirements of 5.3.6.

5.3.6.3 Requirements

The requirements of 5.4, 5.5 and 5.6 shall apply as appropriate.

5.3.7 Crane-switch

5.3.7.1 General

Each hoisting machine shall have one or more crane-switches, operable from the operating control station, for emergency stop of all motion drives and, where necessary, for interrupting the electrical power supply to other equipment.

Load holding devices that cannot continue to hold the load when de-energized (e.g. magnets, pneumatic holding devices) shall be supplied from the supply side of the crane-switch.

Exceptions: Where the emergency stop function is provided by other means, a crane-switch is not required for the following:

- for hoisting machines on which only the hoisting mechanism is power-operated;
- on floor-controlled monorail hoists when the trolley travel is powered by hand or by an electric motor rated at not more than 500 W.

5.3.7.2 Type

The crane-switch shall as a minimum meet the requirements for switches given in IEC 60947-3. This requirement can be fulfilled by one of the devices specified in 5.3.2 a) or c). Contactors selected in accordance with 4.2.2 and used in combination with disconnecting devices may also be used.

5.3.7.3 Requirements

The requirements of 5.3.3 and 5.3.4 shall apply as appropriate. The crane-switch can operate very frequently. All the components (e.g. charging circuitries) shall be selected to allow foreseen switching frequency including the use in commissioning phase.

5.3.8 ~~Special~~ Excepted circuits

~~Special~~ Excepted circuits, which need to be operational during repair and maintenance work, shall be supplied from the supply side of the crane-disconnector specified in 5.3.6 using a dedicated disconnector (see Figure 3) that conforms to the requirements of 5.6.

~~Special~~ Excepted circuits may include but are not limited to the following:

- circuits for plug and socket-outlets and lighting circuits;

- circuits for lifts, repair and maintenance tools and repair cranes installed in hoisting machines;
- circuits for heating, air conditioning and ventilation;
- circuits for electrical equipment fulfilling safety measures, for example anti-collision device, aviation lighting;
- circuits for fire alarm systems;
- communications circuits, data links or program storage devices;
- undervoltage protection circuits that are only provided for automatic tripping in the event of supply failure;
- control circuits for interlocking.

~~Special~~ Excepted circuits shall be so designed and installed that their operation during repair and maintenance work on the hoisting machine does not use unprotected conductor wires, conductor bars or slip-ring assemblies.

~~Special~~ Excepted circuits shall be identifiable by

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

5.4 Devices for ~~switching off~~ removal of power for prevention of unexpected start-up

Devices for ~~switching off~~ removal of power for the prevention of unexpected start-up shall be provided (e.g. where, during maintenance, a start-up of the hoisting machine or part of it can create a hazard). The crane-disconnector (see 5.3.6) fulfils that function for the complete hoisting machine. Where it is necessary to work on individual parts of a hoisting machine, additional devices for switching off shall be provided for each part requiring separate disconnection.

Such devices shall be appropriate and convenient for their intended use, shall be suitably placed and readily identifiable as to their function and purpose.

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

NOTE 2 Removal of power means removal of the connection to the source of electrical energy but does not imply isolation.

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).

NOTE 3 Further information on the location and actuation of devices such as those used for the prevention of unexpected start-up is provided in ISO 14118 ~~(EN 1037)~~.

The following devices that fulfil the isolation function may be provided for these purposes:

- devices described in 5.3.2;
- disconnectors, withdrawable fuse links and withdrawable links only if located in an enclosed electrical operating area (see 3.1.32).

Devices that do not fulfil the isolation function **12** (for example a contactor switched off by a control circuit, or Power Drive System (PDS) with a safe torque off (STO) function in accordance with IEC 61800-5-2) may only be ~~provided where intended to be used for situations that include~~ used for prevention of unexpected start-up during tasks such as:

- 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 (e.g. replacement of plug-in devices without disturbing existing wiring).

~~NOTE 3~~ The selection of a device should take into account, for example, information derived from the risk assessment, intended use and foreseeable misuse of the device and the persons who operate them. ~~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 17.2b)12)).~~

5.5 Devices for ~~disconnecting~~ isolating **13** electrical equipment

Devices shall be provided for isolating (disconnecting ~~(isolating)~~) the electrical equipment or part(s) of the electrical equipment to enable work to be carried out when it is de-energized and isolated. Such devices shall be:

- appropriate and convenient for their intended use;
- suitably placed;
- readily identifiable as to which part(s) or circuit(s) of the equipment is served. Where their function and purpose is not otherwise obvious (e.g. by their location) these devices shall be marked to indicate the extent of the equipment that they isolate.

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 crane-disconnector (see 5.3.6) may, in some cases, fulfil that function. However, where it is necessary to work on individual parts of the electrical equipment of a hoisting machine, or on one of ~~a number of~~ the hoisting 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 hoisting machine, requiring separate isolation.

In addition to the crane-disconnector, 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 3.1.28) and relevant information is provided with the electrical equipment (see 17.2).

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), (e.g. 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 is used within an enclosed electrical operating area (e.g. withdrawable fuse-links, withdrawable links), other means of protection against reconnection (e.g. warning labels in accordance with 16.1) may be provided.

However, when a plug/socket combination in accordance with 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~~ by

- ~~direct contact~~ basic protection **14** (see 6.2 and 6.4);
- ~~indirect contact~~ fault protection **15** (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 60364-4-41:2005. Where those recommended measures are not practicable, for example, due to the physical or operational conditions, other measures from IEC 60364-4-41:2005 may be used.

~~NOTE In IEC 60364-4-41:2005, the terms “basic protection” and “fault protection” are used instead of “protection against direct contact” and “protection against indirect contact”, which are used in this standard.~~

6.2 Basic 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 basic protection ~~against direct contact~~ (e.g. by using barriers, by placing out of reach, using obstacles, using construction or installation techniques that prevent access) as defined in IEC 60364-4-41:2005 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 basic 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 with live parts 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 with live parts 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 60364-4-41:2005 ~~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 Clause 17).

All live parts (including those on the inside of doors) 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 (e.g. the crane-disconnector) 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

- 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 unauthorized closure of the disconnecting device;
- upon closing the door, the interlock is automatically restored;
- all live parts (including those on the inside of doors) 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 about the procedures for the defeat of the interlock is provided with the instructions for use of electrical equipment (see Clause 17);

~~NOTE 2 The special device or tool is intended for use only by skilled or instructed persons (see 17.2b)12)).~~

- means ~~shall be~~ are provided to restrict access to live parts behind doors that are not directly interlocked with the disconnecting means to skilled or instructed persons (see Clause 17).

All parts that are still live after switching off the disconnecting device(s) 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), except for:

~~— 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 crane-supply-switch and the crane-disconnector when they are 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 (e.g. pins), the discharge time to 60 V 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 (e.g. 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~~, for example a warning sign drawing attention to the hazard and stating the delay required shall be provided (see 16.2.3).

~~NOTE This requirement applies for example to capacitors used for power factor correction and filtering and to capacitors in the d.c. bus of adjustable speed drives.~~

NOTE Frequency converters and DC bus supplies could have typically a longer discharge time than 5 s.

6.2.5 Protection by barriers

For protection by barriers, ~~Clause A.2~~ the requirements 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, ~~Clause B.3 of IEC 60364-4-41 shall apply. For protection or by obstacles, Clause B.2~~ the requirements of IEC 60364-4-41 shall apply.

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

6.3 Fault protection ~~against indirect contact~~

6.3.1 General

~~Protection against indirect contact~~ Fault protection 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 following measures, in accordance with 6.3.2 to 6.3.3, shall be applied:

- measures to prevent the occurrence of a touch voltage (see 6.3.2); or
- automatic disconnection of the supply before the time of contact with a touch voltage can become hazardous (see 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~~ touch voltages depends upon a number of factors. These include but are not limited to: value of touch voltage, duration of possible exposure, environmental factors, skin condition.

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~~ IEC 61439-1;
- supplementary or reinforced insulation in accordance with Clause 412 of IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017.

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 and Clause C.3 of~~ IEC 60364-4-41 apply.

6.3.3 Protection by automatic disconnection of supply

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 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~~ the limits specified in Annex A for TN and TT systems. ~~Maximum allowable disconnection times are given in Annex A.~~

This measure necessitates co-ordination between:

- the type of supply systems, the supply source impedance and earthing system;
- the impedance values of the different elements of the line and of the associated fault current paths through the protective bonding ~~system~~ circuit;
- 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.~~

NOTE 1 Details of verification of conditions for protection by automatic disconnection of supply are provided in 18.2.

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.~~

– and one of following: **16**

a) In TN systems, the following protective devices may be used:

- overcurrent protective devices;
- residual current protective devices (RCDs) and associated overcurrent protective device(s).

NOTE 2 The preventive maintenance can be enhanced by use of a residual current monitoring device, RCM, complying with IEC 62020-1.

b) In TT systems, either:

- RCDs and associated overcurrent protective device(s) 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; or
- overcurrent protective devices may be used for fault protection provided a suitably low value of the fault loop impedance Z_S (see A.2.2.3) is permanently and reliably assured.

NOTE 3 The preventive maintenance can be enhanced by use of a residual current monitoring device, RCM, complying with IEC 62020-1.

c) In IT systems, the relevant requirements of IEC 60364-4-41 shall be fulfilled. During an insulation fault an acoustic and optical signal shall be sustained. After annunciation, the acoustic signal may then be manually muted. This can require an agreement between the supplier and user regarding the provision of insulation monitoring devices and/or insulation fault location system(s).

NOTE 4 In large machines, the provision of an insulation fault location system in accordance with IEC 61557-9:2014 can facilitate maintenance.

Where automatic disconnection is provided in accordance with a), and disconnection within the time specified in A.1.1 cannot be assured, supplementary protective bonding shall be provided as necessary to meet the requirements of A.1.3.

Where a power drive system (PDS) is provided, fault protection shall be provided for those circuits of the PDS that are supplied by the converter. Where this protection is not provided within the converter, the necessary protection measures shall be in accordance with the converter manufacturer's instructions.

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 RMS 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 RMS 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 % RMS.

- 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.
- 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).
- 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.
- Plugs and socket-outlets for a PELV circuit shall conform to the following:
 - plugs shall not be able to enter socket-outlets of other voltage systems;
 - 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 (e.g. a motor generator with winding providing equivalent isolation);
- an electrochemical source (e.g. a battery) or another source independent of a higher voltage circuit (e.g. 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 7 details the measures to be taken to protect equipment against the effects of

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

If one of these malfunctions causes the operation of a protective device resulting in the stopping of a motion drive motor, an automatic restart shall be prevented.

NOTE This requirement can be met, for example, by means of:

- a crane-switch which can only be switched on if all operator control devices are in the off position;
- operator control devices which automatically return to the off position.

Where only a part of a hoisting machine or a group of hoisting machines working together in a coordinated manner is affected by the operation of a protective device, such operation shall initiate appropriate control responses to ensure co-ordination (see also 9.3.4).

7.2 Overcurrent protection

7.2.1 General

Overcurrent protection shall be provided where the current in ~~a hoisting machine~~ any 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 used are detailed in 7.2.10.

7.2.2 Supply conductors

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

The supplier of the electrical equipment shall state in the installation ~~diagram~~ document the data necessary for conductor dimensioning (including the maximum cross-sectional area of the supply conductor that can be connected to the terminals of the electrical equipment) and for selecting the overcurrent protective device (see 7.2.10 and 17.2).

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 including also circuits which are supplying control circuit transformers.

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;
- DC power conductors bonded to exposed conductive parts of mobile machines.

Where the cross-sectional area of the neutral conductor is at least equal to, or equivalent to, that of the ~~phase line~~ conductors, it is not necessary to provide overcurrent detection for the neutral conductor nor a disconnecting device for that conductor. For a neutral conductor with a cross-sectional area smaller than that of the associated ~~phase line~~ conductors, the measures detailed in Clause 524 of IEC 60364-5-52:2009 shall apply.

In IT-systems, it is recommended that the neutral conductor is not used. However, where a neutral conductor is used, the measures detailed in 431.2.2 of IEC 60364-4-43:2008 shall apply.

7.2.4 Control circuits

Conductors of control circuits directly connected to the supply voltage ~~and of circuits feeding control circuit transformers~~ shall be protected against overcurrent in accordance with 7.2.3.

Conductors of control circuits supplied by a ~~control circuit~~ transformer or DC supply shall be protected against overcurrent (see also 9.4.3.1):

- in control circuits connected to the protective bonding circuit, by inserting an overcurrent protective device into the switched conductor;
- in control circuits not connected to the protective bonding circuit:
 - ~~a) where the same cross-sectional area conductors are used in all control circuits, by inserting an overcurrent protective device into the switched conductor; and~~

- ~~b) where different cross sectional area conductors are used in different subcircuits, by inserting an overcurrent protective device into both switched and common conductors of each subcircuit.~~
- a) where all control circuits of the equipment have the same current-carrying capacity, by inserting an overcurrent protective device into the switched conductor; or
- b) where control circuits of the equipment have different current-carrying capacity, by inserting an overcurrent protective device into both switched and common conductors of each control circuit.

Exception: Where the supply unit provides current limiting below the current-carrying capacity of the conductors in a circuit and below the current rating of connected components, no separate overcurrent protective device is required.

7.2.5 Socket outlets and their associated conductors

Overcurrent protection shall be provided for the circuits feeding the general purpose socket outlets intended primarily for supplying power to maintenance equipment. Overcurrent protective devices shall be provided in the unearthed live conductors of each circuit feeding such socket outlets. See also 15.1.

7.2.6 Lighting circuits

All unearthed conductors of circuits supplying lighting shall be protected against the effects of short circuits by the provision of overcurrent devices separate from those protecting other circuits.

7.2.7 Transformers

Transformers shall be protected ~~against~~ by an overcurrent protective device having a type and settings in accordance with the transformer manufacturer's instructions. Such protection shall (see also 7.2.10)

- avoid nuisance tripping due to transformer magnetizing inrush currents;
- avoid a winding temperature rise in excess of the permitted value for the insulation class of transformer when it is subjected to the effects of a short circuit at its secondary terminals.

7.2.8 Location of overcurrent protective devices

An overcurrent protective device shall be located at the point where a reduction in the cross-sectional area of the conductors or another change reduces the current-carrying capacity of the conductors, except where all the following conditions are satisfied.

- The current-carrying capacity of the conductors is at least equal to that of the load.
- The part of the conductor(s) between the point of reduction of the current-carrying capacity and the position of the overcurrent protective device is no longer than 3 m.
- The conductors are installed in such a manner as to reduce the possibility of a short circuit, for example, protected against mechanical damage by an enclosure or a duct, or by other suitable means.

7.2.9 Overcurrent protective devices

The rated short-circuit breaking capacity shall be at least equal to the prospective fault current at the point of installation. Where the short-circuit current to an overcurrent protective device can include additional currents other than from the supply (e.g. from motors, from power factor correction capacitors), those currents shall be taken into consideration.

A lower breaking capacity is permitted where another protective device (e.g. the overcurrent protective device for the supply conductors (see 7.2.2) having the necessary breaking capacity is installed on the supply side. In that case, the characteristics of the two devices shall be

coordinated so that the let-through energy (I^2t) of the two devices in series does not exceed that which can be withstood without damage to the overcurrent protective device on the load side and to the conductors protected by that device (see Annex A of IEC 60947-2:2016).

NOTE The use of such a coordinated arrangement of overcurrent protective devices can result in the operation of both overcurrent protective devices.

Where fuses are provided as overcurrent protective devices, a type readily available in the country of use shall be selected, or arrangements shall be made for the supply of spare parts.

7.2.10 Rating and setting of overcurrent protective devices

The rated current of fuses or the setting current of other overcurrent protective devices shall be selected as low as possible but adequate for the anticipated overcurrents (e.g. during starting of motors or energizing of transformers). When selecting those protective devices, consideration shall be given to the protection of switching devices against damage due to overcurrents ~~(for example, welding of the switching device contacts)~~.

The rated current or setting of an overcurrent protective device for conductors is determined by the current-carrying capacity of the conductors to be protected in accordance with 12.4, Clause C.3 and the maximum allowable interrupting time t in accordance with Clause C.4, taking into account the needs of coordination with other electrical devices in the protected circuit.

In case of multi-motor drives, the overcurrent protection in the feeding system might not be able to protect a single branch cable in case of a short circuit failure. Additional protective measures or dimensioning of branch cables with respect to the maximum short-circuit current are required.

7.3 Protection of motors against overheating

7.3.1 General

Protection of motors against overheating shall be provided for each motor rated at more than 2 kW.

Exceptions: In applications where an automatic interruption of the motor operation is unacceptable (e.g. in load holding devices), the means of detection shall give a warning signal to which the operator can respond.

Protection of motors against overheating can be achieved by

- overload protection (7.3.2);

NOTE 1 Overload protective devices detect the time and current relationships (I^2t) in a circuit that are in excess of the rated full load of the circuit and initiate appropriate control responses.

- over-temperature protection (7.3.3); or

NOTE 2 Temperature detection devices sense over-temperature and initiate appropriate control responses.

- current-limiting protection.

Automatic restarting of any motor after the operation of protection against overheating shall be prevented where this can cause a hazardous situation or damage to the machine or to the work in progress.

7.3.2 Overload protection

Where overload protection is provided, detection of overload(s) shall be provided in each live conductor except for the neutral conductor. However, where the motor overload detection is not used for cable overload protection (see also Clause C.3), ~~the number of overload detection devices may be reduced at the request of the user (see also Annex B)~~ detection of overload

may be omitted in one of the conductors. For motors having single-phase or DC power supplies, detection in only one unearthed live conductor is permitted.

Where overload protection is achieved by switching off, the switching device shall switch off all live conductors. The switching of the neutral conductor is not necessary for overload protection.

Where motors with special duty ratings are required to start or to brake frequently (e.g. motors for rapid traverse, locking, rapid reversal, ~~sensitive drilling~~, plugging and inching), it can be difficult to provide overload protection with a time constant comparable with that of the winding to be protected. Protective devices designed to accommodate special duty motors or over-temperature protection (see 7.3.3) can be necessary.

For motors that cannot be overloaded (e.g. torque motors, motion drives that either are protected by mechanical overload protection devices or are adequately dimensioned), overload protection is not required.

7.3.3 Over-temperature protection

The provision of motors with over-temperature protection (~~see~~ in accordance with IEC 60034-11) is recommended in situations where the cooling can be impaired. Depending upon the type of motor, protection under stalled rotor or loss of phase conditions is not always ensured by over-temperature protection, and additional protection should then be provided.

Over-temperature protection is also recommended for motors that cannot be overloaded (e.g. torque motors, motion drives that are either protected by mechanical overload protection devices or are adequately dimensioned), where the possibility of over-temperature exists (e.g. due to reduced cooling).

NOTE Cooling can be impaired, for example, due to dusty environment and when motors with shaft-mounted fans are driven at low speeds.

~~7.3.4 Current limiting protection~~

~~Where protection against the effects of overheating in three phase motors is achieved by current limitation, the number of current limitation devices may be reduced from 3 to 2 (see 7.3.2). For motors having single phase a.c. or d.c. power supplies, current limitation in only one unearthed live conductor is permitted.~~

7.4 Protection against abnormal temperature ~~protection~~

~~Resistance heating~~ Braking resistors or other ~~circuits~~ equipment that are capable of attaining or causing abnormal temperatures (e.g. due to short-time rating or loss of cooling medium) and therefore can cause a hazardous situation shall be provided with suitable detection to initiate an appropriate control response.

7.5 Protection against the effects of supply interruption or voltage reduction and subsequent restoration

Where a supply interruption or a voltage reduction can cause a hazardous condition, such as damage to the hoisting machine, or to the load, undervoltage protection shall be provided (e.g. by switching off the hoisting machine and/or engaging mechanical brakes) at a predetermined voltage level.

NOTE Depending on the risk assessment, undervoltage protection ~~may~~ can be omitted on a manually controlled hoisting machine.

Where the operation of the hoisting machine can allow for an interruption or a reduction of the voltage for a short time period, delayed undervoltage protection may be provided. The operation of the undervoltage device shall not impair the operation of any stopping control of the hoisting machine.

Upon restoration of the voltage or upon switching on the incoming supply, automatic or unexpected restarting of the hoisting machine shall be prevented where such a restart can cause a hazardous situation.

Where only a part of the hoisting machine or of the group of hoisting machines working together in a coordinated manner is affected by the voltage reduction or supply interruption, the undervoltage protection shall initiate appropriate control ~~responses~~ commands to ensure coordination.

7.6 Motor overspeed protection

Overspeed protection shall be provided where overspeeding can occur and could possibly cause a hazardous situation taking into account measures in accordance with 9.2.5.5. and 9.3.3. Overspeed protection shall initiate appropriate control responses and shall prevent automatic restarting.

The overspeed protection should operate in such a manner that the mechanical speed limit of the motor or its load is not exceeded.

NOTE 1 This protection can consist, for example, of a centrifugal switch, speed limit monitor, or speed monitoring built into the drive system.

NOTE 2 Inadmissible high speeds could occur, for example, in hoisting drives equipped with DC motors or with variable speed drives.

7.7 Additional earth fault/residual current protection

In addition to providing overcurrent protection for automatic disconnection as described in 6.3, earth fault/residual current protection can be provided to reduce damage to equipment due to earth fault currents less than the detection level of the overcurrent protection.

The setting of the devices shall be as low as possible consistent with correct operation of the equipment.

If fault currents with DC components are possible, an RCD of type B in accordance with IEC 60755:2017 can be required. **17**

7.8 Phase sequence protection

Where an incorrect phase sequence of ~~the~~ any supply voltage (including alternative power supply, e.g. generator in case of emergency) can cause a hazardous ~~condition~~ situation or damage to the hoisting machine, phase sequence protection shall be provided.

NOTE Conditions of use that can lead to an incorrect phase sequence include:

- a hoisting machine transferred from one supply to another;
- a mobile crane with a facility for connection to an external power supply.

~~A hoisting machine with provision for connection of an auxiliary electric power supply (for example, for repairs) or an alternative power supply (for example, in case of emergency) shall have a phase sequence protection device to ensure the correct motor rotation.~~

A hoisting machine with provision of an electrical power supply for auxiliary devices (e.g. for repairs with auxiliary hoists) shall have a phase sequence protection device to ensure the correct motor rotation.

7.9 Protection against overvoltages due to lightning and to switching surges ~~and lightning~~

Surge protective devices (SPDs) can be provided to protect against the effects of overvoltages due to lightning or to switching surges.

Where provided,

- ~~devices~~ SPDs for the suppression of overvoltages due to lightning shall be connected to the incoming terminals of the crane-supply-switch and/or crane-disconnector;
- ~~devices~~ SPDs for the suppression of overvoltages due to switching surges shall be connected ~~across the terminals of all~~ as necessary for equipment requiring such protection.

NOTE 1 Information about the correct selection and installation of SPDs is given, for example, in IEC 60364-4-44, IEC 60364-5-53, IEC 61643-12, IEC 62305-1 and IEC 62305-4.

NOTE 2 Equipotential bonding of the machine, its electrical equipment and extraneous conductive parts to a common bonding network of the building/site can help mitigate electromagnetic interference, including the effects of lightning, on the equipment.

If the risk assessment requires, outdoor cranes shall be equipped with a lightning protection system including the following.

a) Air-termination systems

A separate air termination might not be necessary if the structure of the crane performs this function.

b) Down-conductor systems

The structure of the hoisting machine – with all hinged and other moving joints by-passed by a grounding conductor – can be used as a down conductor.

c) Earth-termination systems

The earth-termination may include grounding collectors to crane rails.

NOTE 1 Guidance for the risk assessment and for lightning protection systems is given in the IEC 62305 series.

NOTE 2 There ~~may~~ can be national requirements for lightning protection.

7.10 Short-circuit current rating

The short-circuit current rating of the electrical equipment shall be determined. This can be done by the application of design rules or by calculation or by test.

NOTE The short-circuit current rating can be determined, for example, in accordance with IEC 61439-1, IEC 60909-0, IEC TR 60909-1, or IEC TR 61912-1.

8 Equipotential bonding

8.1 General

This Clause 8 provides requirements for protective bonding and functional bonding. Figure 6 illustrates those concepts.

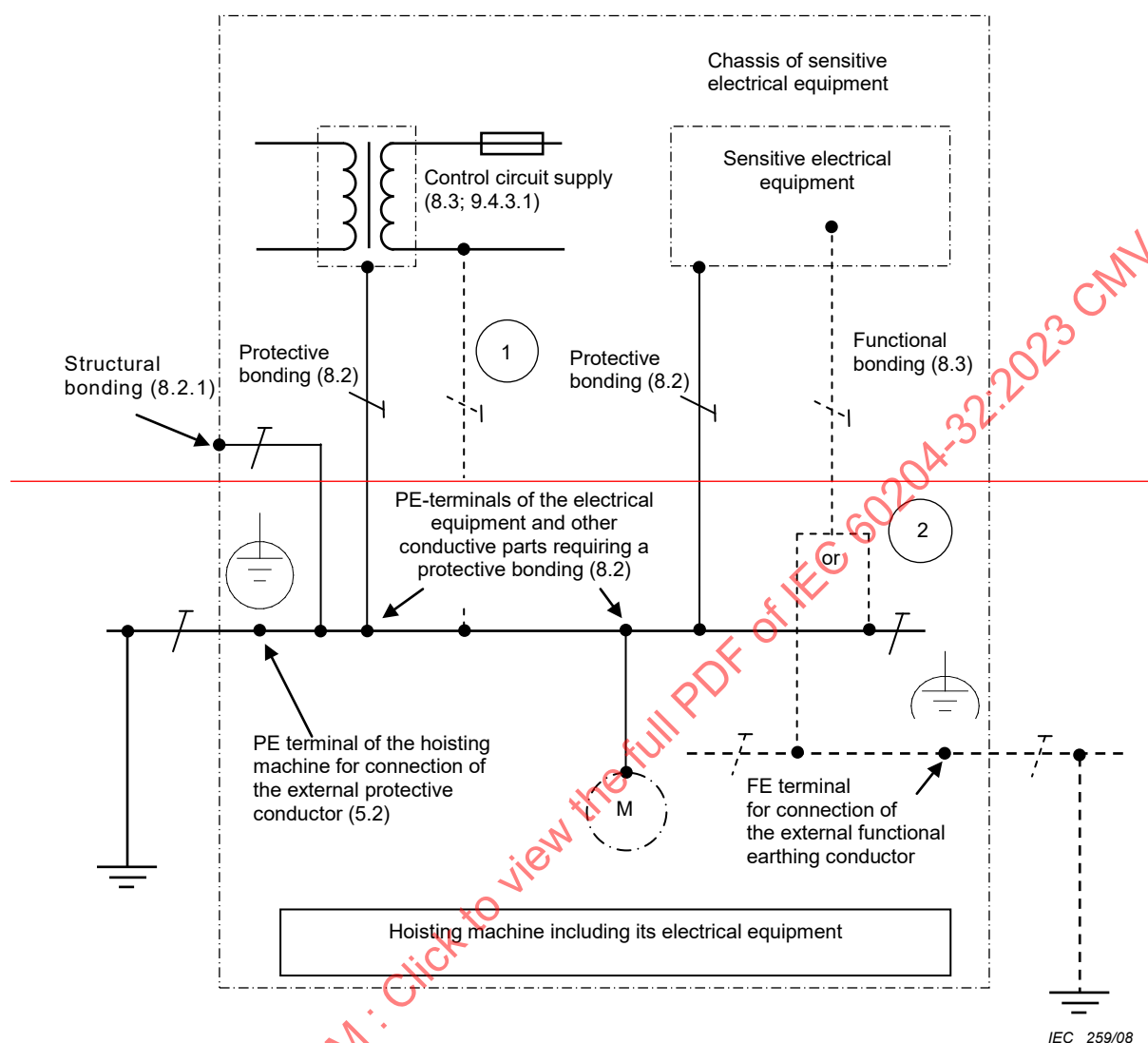
Protective bonding is a basic provision for fault protection to enable protection of persons against electric shock ~~from indirect contact~~ (see 6.3.3 and 8.2).

The objective of functional bonding (see 8.3) is to ~~minimize~~ reduce:

- the consequence of an insulation failure which could affect the operation of the hoisting machine;
- ~~the consequences of~~ electrical disturbances to sensitive electrical equipment which could affect the operation of the hoisting machine;
- induced currents from lightning which could damage the electric equipment.

~~Normally,~~ Functional bonding is achieved by connection to the protective bonding circuit, but, where the level of electrical disturbances on the protective bonding circuit is not sufficiently low for proper functioning of electrical equipment, it can be necessary to ~~connect the functional~~

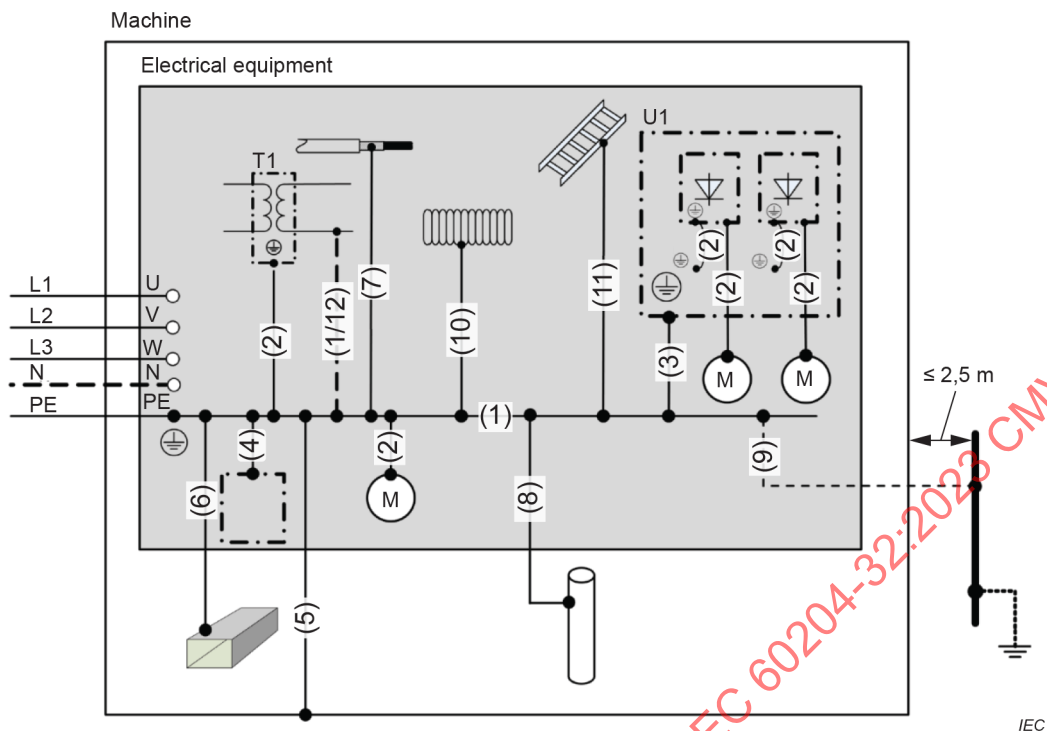
~~bonding circuit to a separate functional earthing conductor~~ use separate conductors for protective and functional bonding (see Figure 6 **18**).



~~Optional connections~~

- ~~1 Functional bonding (8.3) including protective bonding (8.2)~~
- ~~2 Functional bonding only (8.3) either to the protective conductor or to functional earthing conductor~~

~~NOTE The functional earthing conductor was previously referred to as 'noiseless earth conductor' and the 'FE' terminal was previously designated 'TE' (see IEC 60445)~~



Protective bonding circuit:	
(1)	Interconnection of protective conductor(s) and the PE terminal
(2)	Connection of exposed conductive parts
(3)	Protective conductor connected to an electrical equipment mounting plate used as a protective conductor
(4)	Connection of conductive structural parts of the electrical equipment
(5)	Conductive structural parts of the machine
Parts connected to the protective bonding circuit which are not to be used as protective conductor:	
(6)	Metal ducts of flexible or rigid construction
(7)	Metallic cable sheaths or armouring
(8)	Metallic pipes containing flammable materials
(9)	Extraneous conductive parts, if earthed independently from the power supply of the machine and liable to introduce a potential, generally the earth potential, (see 17.2 d)), e.g.: – metallic pipes, – fences, – ladders, – handrails.
(10)	Flexible or pliable metal conduits
(11)	Protective bonding of support wires, cable trays and cable ladders
Connections to the protective bonding circuit for functional reasons:	
(12)	Functional bonding
Legend to reference designations:	
T1	Auxiliary transformer
U1	Mounting plate of electrical equipment

Figure 6 – Example of equipotential bonding for electrical equipment of a hoisting machine

8.2 Protective bonding circuit

8.2.1 General 19

The protective bonding circuit consists of the interconnection of:

- PE terminal(s) (see 5.2);
- the protective conductors ~~in the equipment of the hoisting machine~~ (see 3.1.69), including sliding contacts where they are part of the circuit;
- the conductive structural parts and exposed conductive parts of the electrical equipment ~~and the hoisting machine~~;
Exception: see 8.2.5
- those conductive structural parts of the hoisting machine used for protective bonding.

~~On mobile cranes with on-board power supplies, the protective circuits, the exposed conductive parts, and the extraneous conductive parts shall all be connected to a protective bonding terminal to provide protection against electric shock.~~

~~NOTE~~ Exception: For mobile cranes, when the supply of electrical energy is self-contained ~~within stationary, mobile, or movable items of equipment~~, and when there is no external supply connected (e.g. when an on-board battery charger is not connected), there is no need to connect such equipment to an external protective conductor.

All parts of the protective bonding circuit shall be so designed that they are capable of withstanding the highest thermal and mechanical stresses that can be caused by earth-fault currents that could flow in that part of the protective bonding circuit.

~~Where the conductance of structural parts of the electrical equipment or of the hoisting machine is less than that of the smallest protective conductor connected to the exposed conductive parts, a supplementary bonding conductor shall be provided. This supplementary bonding conductor shall have a cross-sectional area not less than half that of the corresponding protective conductor.~~

If an IT distribution system is used, the hoisting machine structure shall be part of the protective bonding circuit and insulation monitoring shall be provided. See 6.3.3 c).

Conductive structural parts of equipment in accordance with 6.3.2.2 need not be connected to the protective bonding circuit. Extraneous conductive parts which form the structure of the hoisting machine need not be connected to the protective bonding circuit where all the equipment provided is in accordance with 6.3.2.2.

Exposed conductive parts of equipment in accordance with 6.3.2.3 shall not be connected to the protective bonding circuit.

8.2.2 Protective conductors

Protective conductors shall be identified in accordance with 13.2.2.

Copper conductors are preferred. Where a conductor material other than copper is used, its electrical resistance per unit length shall not exceed that of the allowable copper conductor, and such conductors shall be not less than 16 mm² in cross-sectional area for reasons of mechanical durability 20.

~~The cross-sectional area of protective conductors shall be determined in accordance with the requirements of~~

~~— IEC 60364-5-54, 543, or~~

~~— IEC 60439-1, 7.4.3.1.7, as appropriate.~~

~~This requirement is met in most cases where the relationship between the cross-sectional area of the phase conductors associated with that part of the equipment and the cross-sectional area of the associated protective conductor is in accordance with Table 1.~~

Metal enclosures or frames or mounting plates of electrical equipment, connected to the protective bonding circuit, may be used as protective conductors if they satisfy the following three requirements:

- their electrical continuity shall be assured by construction or by suitable connection so as to ensure protection against mechanical, chemical or electrochemical deterioration;
- they comply with the requirements of 543.1 of IEC 60364-5-54:2011;
- they shall permit the connection of other protective conductors at every predetermined tap-off point.

The cross-sectional area of protective conductors shall either be calculated in accordance with 543.1.2 of IEC 60364-5-54:2011 or selected in accordance with Table 1 (see 5.2). See also 8.2.6 and 17.2 d) of this document.

Each protective conductor shall:

- be part of a multicore cable; or
- be in a common enclosure with the line conductor; or
- have a cross-sectional area of at least
 - 2,5 mm² Cu or 16 mm² Al if protection against mechanical damage is provided,
 - 4 mm² Cu or 16 mm² Al if protection against mechanical damage is not provided.

NOTE 1 The use of steel for a protective conductor is not excluded.

A protective conductor not forming part of a cable is considered to be mechanically protected if it is installed in a conduit, trunking or protected in a similar way.

The following parts of the machine and its electrical equipment shall be connected to the protective bonding circuit but shall not be used as protective conductors:

- metal ducts of flexible or rigid construction;
- metallic cable sheaths or armouring;
- metallic pipes containing flammable materials such as gases, liquids, powder.
- flexible or pliable metal conduits;
- conductive structural parts of the hoisting machine;
- flexible metal parts, support wires, cable trays and cable ladders.

NOTE 2 Information on cathodic protection is provided in 542.2.5 and 542.2.6 of IEC 60364-5-54:2011.

8.2.3 Continuity of the protective bonding circuit

~~All exposed conductive parts shall be connected to the protective bonding circuit in accordance with 8.2.1.~~

~~Exception: See 8.2.5.~~

Where a part is removed for any reason (e.g. routine maintenance), the protective bonding circuit for the remaining parts shall not be interrupted.

Connection and bonding points shall be so designed that their current-carrying capacity is not impaired by mechanical, chemical, or electrochemical influences. Where enclosures and

conductors of aluminium or aluminium alloys are used, particular consideration should be given to the possibility of electrolytic corrosion.

~~Metal ducts of flexible or rigid construction and metallic cable sheaths shall not be used as protective conductors. Nevertheless, such metal ducts and the metal sheathing of all connecting cables (for example, cable armouring, lead sheath) shall be connected to the protective bonding circuit.~~

Where the electrical equipment is mounted on lids, doors, or cover plates, continuity of the protective bonding circuit shall be ensured and a protective conductor (see 8.2.2) is recommended. Otherwise, fastenings, hinges or sliding contacts designed to have a low resistance shall be used (see 18.2.2, Test 1).

The continuity of the protective conductor in cables that are exposed to the risk of damage (e.g. flexible trailing cables) shall be ensured by appropriate measures (e.g. monitoring).

For requirements for the continuity of the protective conductor using conductor wires, conductor bars and slip-ring assemblies, see 12.7.2.

Rails of hoisting machines may be connected to the protective bonding circuit. However, they shall not replace the protective conductor (e.g. cable, conductor wire or conductor bar) from the supply source to the hoisting machine.

The electrical equipment of hoisting machines intended to be used at different sites (transportable hoisting machines) shall conform to the requirements of this document for all expected supply earthing systems. When used with IT or TT systems, the protective bonding circuit of the hoisting machine shall be connected to the earthing system of the site.

8.2.4 Exclusion of switching devices from the protective bonding circuit

The protective bonding circuit shall not incorporate a switching device or an overcurrent protective device (e.g. switch, fuse) or other means of interruption.

~~No means of interruption of the protective bonding conductor shall be provided.~~

Exceptions:

- Links for test or measurement purposes that cannot be opened without the use of a tool and that are located in an enclosed electrical operating area.
- Where the continuity of the protective bonding circuit can be interrupted by means of removable current collectors or plug/socket combinations, the protective bonding circuit shall be interrupted by a first-make last-break contact. This also applies to removable or withdrawable plug-in units (see also 13.4.5).

8.2.5 Parts that need not be connected to the protective bonding circuit

It is not necessary to connect exposed conductive parts to the protective bonding circuit where those parts are mounted so that they do not constitute a hazard because

- they cannot be touched on large surfaces or grasped with the hand and they are small in size (less than approximately 50 mm × 50 mm); or
- they are located so that either contact with live parts, or an insulation failure, is unlikely.

This applies to small parts such as screws, rivets, and nameplates, and to parts inside an enclosure, irrespective of their size (e.g. electromagnets of contactors or relays and mechanical parts of devices).

NOTE Further information can be found in 410.3.9 of IEC 60364-4-41:2005.

8.2.6 Protective conductor connecting points

All protective conductors shall be terminated in accordance with 13.1.1. The protective conductor connecting points shall have no other function and shall not be used, for example, to attach or connect appliances or parts.

~~Each protective conductor connecting point shall be marked or labelled as such using the symbol IEC 60417-5019 (2002-10):~~



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

~~When a mobile crane with an on-board power supply is also capable of being connected to an external incoming supply, the protective bonding terminal shall be the connection point for the external protective conductor.~~

Each protective conductor connecting point shall be marked or labelled as such using the symbol IEC 60417-5019 (2006-08), as illustrated in Figure 7, or with the letters PE, the graphical symbol being preferred, or by use of the bicolour combination GREEN-AND-YELLOW, or by any combination of these.

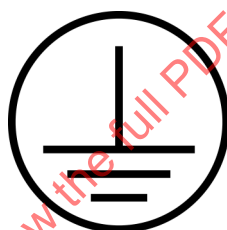


Figure 7 – Symbol IEC 60417-5019: Protective earth

8.2.7 Mobile hoisting machines 21

On mobile hoisting machines with on-board power supplies, the protective conductors, the conductive structural parts of the electrical equipment, and those extraneous conductive parts which form the structure of the hoisting machine shall all be connected to a protective bonding terminal to provide protection against electric shock. When this mobile hoisting machine with an on-board power supply is also capable of being connected to an external incoming supply, the protective bonding terminal shall be the connection point for the external protective conductor.

8.2.8 Additional ~~protective bonding~~ requirements for electrical equipment having earth leakage currents higher than 10 mA AC or DC

NOTE 1 Earth leakage current is defined as “current flowing from the live parts of an installation to earth, in the absence of an insulation fault” (IEV 442-01-24). This current ~~may~~ can have a capacitive component including that resulting from the deliberate use of capacitors.

NOTE 2 Most adjustable speed electrical power drive systems that conform to relevant parts of IEC 61800 will have an earth leakage current greater than 3,5 mA AC. A touch current measurement method is specified as a type test in IEC 61800-5-1 to determine the earth leakage current of an adjustable speed electrical power drive system.

Where electrical equipment has an earth leakage current (e.g. adjustable speed electrical power drive systems and information technology equipment) that is greater than 10 mA AC or DC in any incoming supply, one or more of the following conditions for the associated protective bonding circuit shall be satisfied.

- a) The protective conductor shall be part of the power supply cable or an enclosed busbar system and shall have a cross-sectional area of at least 1,5 mm² Cu through its total run.
- b) The protective conductor shall have a cross-sectional area of at least 10 mm² Cu or 16 mm² Al, through its total run.
- c) Where the protective conductor has a cross-sectional area of less than 10 mm² Cu or 16 mm² Al, a second protective conductor of at least the same cross-sectional area ~~shall be~~ is provided up to a point where the protective conductor has a cross-sectional area not less than 10 mm² Cu or 16 mm² Al.

~~NOTE~~ This can require that the electrical equipment has a separate terminal for a second protective conductor.

- d) ~~automatic disconnection of~~ The supply is automatically disconnected in case of loss of continuity of the protective conductor.

To prevent difficulties associated with electromagnetic disturbances, 4.4.2 also applies to the installation of duplicate protective conductors.

~~In addition, a warning label shall be provided adjacent to the PE terminal and where necessary on the nameplate of the electrical equipment. The information provided under 17.2b)1) shall include information about the leakage current and the minimum cross-sectional area of the external protective conductor.~~

A statement shall be given in the instructions for installation that the equipment shall be installed as described in this 8.2.8.

NOTE 3 A warning label can also be provided adjacent to the PE terminal to state that the protective conductor current exceeds 10 mA.

8.3 Functional bonding

Protection against maloperation as a result of insulation failures can be achieved by connecting to a common conductor in accordance with 9.4.3.1.

For recommendations regarding functional bonding to avoid maloperation due to electromagnetic disturbances, see 4.4.2 and Annex G.

Functional bonding connecting points should be marked or labelled as such using the symbol IEC 60417-5020 (2002-10) (see Figure 4).

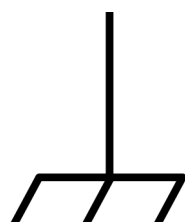


Figure 8 – Symbol IEC 60417-5020: Frame or chassis

8.4 Measures to ~~limit~~ restrict the effects of high leakage current

The effects of high leakage current can be restricted to the equipment having high leakage current by connection of that equipment to a dedicated supply transformer having separate windings. ~~Where a transformer is provided for this purpose,~~ The protective bonding circuit shall be connected to exposed conductive parts of the equipment and, in addition, to the secondary winding of the transformer. The protective conductor(s) between the equipment and the secondary winding of the transformer shall conform to one or more of the arrangements described in 8.2.8.

9 Control circuits and control functions

9.1 Control circuits

~~NOTE – Not applicable for hand-held direct-control devices (see 3.36).~~

9.1.1 General

Subclause 9.1 is not applicable for hand-held direct-control devices (see 3.1.45).

9.1.2 Control circuit supply

~~Where control circuits are supplied from an a.c. source, control transformers shall be used for supplying the control circuits. Such transformers shall have separate windings.~~

Where control circuits are supplied from an AC source, transformers or switch mode power supply units having separate windings shall be used to separate the power supply from the control supply, for example: **22**

- transformers having separate windings in accordance with IEC 61558-2-2;
- switch mode power supply units in accordance with IEC 61558-2-16 fitted with transformers having separate windings;
- low voltage power supplies in accordance with IEC 61204-7 fitted with transformers having separate windings.

Where several transformers are used, it is recommended that the windings of those transformers be connected in such a manner that the secondary voltages are in phase.

Where DC control circuits derived from an AC supply are connected to the protective bonding circuit (see 8.2.1), they shall be supplied from a separate winding of the AC control circuit transformer or by another control circuit transformer.

~~NOTE 1~~ Switch-mode units fitted with transformers having separate windings in accordance with IEC 61558-2-17 conform to this requirement.

Exception: Transformers or switch mode power supply units fitted with transformers are not mandatory for hoisting machines with a single motor starter and/or a maximum of two control devices (for example, interlock device, start/stop control station).

~~NOTE 2 – This exception concerns for example small hoisting machines with one hoisting motor with an UP and DOWN motion and upper position limiter. For testing and/or maintenance purposes, hoisting machines with more than one electrical motion drive should incorporate means to energize a drive control circuit without energizing its power circuit.~~

9.1.3 Control circuit voltages

The nominal value of the control voltage shall be consistent with the correct operation of the control circuit. ~~The nominal voltage shall not exceed 277 V when supplied from a transformer.~~

The nominal voltage of AC control circuits should preferably not exceed

- 230 V for circuits with 50 Hz nominal frequency,
- 277 V for circuits with 60 Hz nominal frequency.

The nominal voltage of DC control circuits should preferably not exceed 220 V.

9.1.4 Protection

Control circuits shall be provided with overcurrent protection in accordance with 7.2.4 and 7.2.10.

9.2 Control functions

~~NOTE 1 Information on the safety related aspects of control functions, including those implemented using programmable electronic systems, is given in ISO 12100 2:2003, ISO 13849 1:2006, ISO 13849 2:2003, and IEC 62061. See also 9.4.~~

~~NOTE 2 This subclause does not specify requirements for the equipment used to implement control functions. Examples of such requirements are given in Clause 10.~~

9.2.1 General

Subclause 9.2 does not specify requirements for the equipment used to implement control functions. Examples of such requirements are given in Clause 10.

~~9.2.1 Start functions~~

~~Start functions shall operate by energizing the relevant circuit (see 9.2.5.2).~~

9.2.2 Categories of Stop functions

There are three categories of stops as follows:

- stop category 0: stopping by immediate removal of power to the hoisting machine actuators (i.e. an uncontrolled stop – see 3.1.85);
- stop category 1: a controlled stop (see 3.1.17) with power available to the hoisting machine actuators to achieve the stop and then removal of power when the stop is achieved;
- stop category 2: a controlled stop with power remaining available to the hoisting machine actuators.

~~When using a stop function as a safety related control function, measures against inadmissible control deviations (see 9.4.4) shall be provided (e.g. using drive systems that provide appropriate safety related control functions in accordance with IEC 61800 5 2).~~

NOTE For removal of power, it can be sufficient to remove the power needed to generate a torque or force. This can be achieved by disconnecting, switching off, or by electronic means (e.g. a PDS in accordance with the IEC 61800 series), etc.

9.2.3 Operating modes

Each hoisting machine can have one or more operating modes **23** (for example manual mode, automatic mode, setting mode, maintenance mode) determined by the type of hoisting machine and its application. ~~When a hazardous situation can result from a mode selection, unauthorized and/or inadvertent selection shall be prevented by suitable means (for example, key operated switch, access code).~~

Where machinery has been designed and constructed to allow its use in several control or operating modes requiring different protective measures and having a different impact on safety, it shall be fitted with a mode selector which can be locked in each position (for example key operated switch or electrical interlocking). Each position of the selector shall be clearly identifiable and shall correspond to a single operating or control mode.

The selector may be replaced by another selection method which restricts the use of certain functions of the machinery to certain categories of operator (for example access code).

Mode selection by itself shall not initiate hoisting machine operation. A separate actuation of the start control shall be required.

For each specific operating mode, the relevant safety functions and/or protective measures shall be implemented.

Indication of the selected operating mode shall be provided (e.g. the position of a mode selector, the provision of an indicating light, a visual display indication).

9.2.4 Suspension of safeguarding

Where it is necessary to provide a means of suspending a particular safety function or protective measure during setting, testing and maintenance activities, such means shall be designed with due consideration of foreseeable misuse (see ~~5.3 c of ISO 12100-1~~ 5.4 c) of ISO 12100:2010).

During actual suspension of the safety function or protective measure, protection shall be ensured by

- disabling all other operating (control) modes; and
- other relevant means (see ~~4.11.9 of ISO 12100-2:2003~~ ISO 12100:2010), which can include, for example, one or more of the following:
 - initiation of operation by a hold-to-run device or by a similar control device;
 - a portable control station with an emergency stop device and, where appropriate, an enabling device. Where a portable control station is in use, initiation of motion shall only be possible from that control station;
 - a cableless control station with a device to initiate stop functions in accordance with 9.2.7.3 and, where appropriate, an enabling device. Where a cableless control station is in use, initiation of motion shall only be possible from that control station;
 - limitation of the speed or the power of motion;
 - limitation of the range of motion.

Additional requirements and limitations for suspension of particular safety functions may be defined in the specific product standards.

For example, the suspension of overload protection may be prohibited even during setting, testing and maintenance activities in case there is a stability problem with the particular hoisting machine.

9.2.5 Operation

9.2.5.1 General

~~The necessary~~ Safety functions and/or protective measures (for example interlocks (see 9.3)) shall be provided ~~for safe operation~~ where required to reduce the possibility of hazardous situations.

Measures shall be taken to prevent movement of the hoisting machine in an unintended or unexpected manner after any stopping of the hoisting machine (e.g. due to locked-off condition, power supply fault, battery replacement, lost signal condition with cableless control).

Manually controlled hoisting machines shall use either hold-to-run controls or two-position enabling devices (see 10.9) for operation; this requirement does not apply to cabin controlled hoisting machines with over-travel limiting devices where no hazardous condition can occur.

On a hoisting machine with more than one operator control station for the same motion drive, (e.g. cabin control and floor control), only one operator control station shall be enabled at any given time. For emergency stop, see 9.2.5.4.2 and 10.7. Means shall be provided to indicate the operational status of the operator control station.

9.2.5.2 Start

Start functions shall operate by energizing the relevant circuit.

The start of an operation (e.g. a motion) shall be possible only when all of the relevant safety functions and/or protective measures are in place and are operational except for conditions, as described in 9.2.4.

On those hoisting machines where safety functions and/or protective measures cannot be applied for certain operations (e.g. a particular motion), manual control of such operations shall be by hold-to-run controls, together with enabling devices, as appropriate.

The provision of acoustic and/or visual warning signals before starting machine operation which can result in hazardous situation shall be considered during the risk assessment. Where the risk assessment determines that either or both are required the emission level of these warning signals shall be suitable for the intended environment.

Suitable interlocks shall be provided to secure correct sequential starting.

In the case of hoisting machines which require the use of more than one control station to initiate a start, each of these control stations shall have a separate manually actuated start control device. The conditions to initiate a start shall be:

- all required conditions for hoisting machine operation shall be met; and
- all start control devices shall be in the released (off) position; then
- all start control devices shall be actuated concurrently (see 3.1.10).

9.2.5.3 Stop

Stop category 0 and/or stop category 1 and/or stop category 2 stop functions shall be provided as indicated by the risk assessment and the functional requirements of the hoisting machine (see 4.1, 9.4.1. and 9.4.4).

NOTE The supply disconnecting and switching devices (see 5.3) when operated achieve a stop category 0.

Stop functions shall override related start functions (see 9.2.5.2).

Where required, facilities to connect protective devices and interlocks shall be provided. If such a protective device or interlock causes a stop of the hoisting machine, it may be necessary for that condition to be signalled to the logic of the control system. The reset of the stop function shall not initiate any hazardous situation.

For movements that can be affected by gravity or other external forces (e.g. wind force), keeping the motion at stop should not be accomplished by the drive system but be secured by means not depending on power supply (e.g. by a mechanical brake). See also 9.3.5, 9.4.3.2 and 14.7.

9.2.5.4 Emergency operations (emergency stop, emergency switching-off)

9.2.5.4.1 General requirements

This document specifies the requirements for the emergency stop and the emergency switching-off functions of the emergency operations listed in Annex E, both of which are, in this document, initiated by a single human action.

Emergency stop and emergency switching-off are complementary protective measures that are not primary means of risk reduction for hazards (e.g. crushing, impact, electric shock or burn) at a hoisting machine (see ISO 12100:2010).

Once active operation of an emergency stop (see 10.7) or emergency switching-off (see 10.8) actuator has ceased following a command, the effect of this command shall be sustained until it is reset. This reset shall be possible only by a manual action at that location where the command has been initiated. The reset of the command shall not restart the hoisting machine but only permit restarting.

It shall not be possible to restart the hoisting machine until all emergency stop commands have been reset. It shall not be possible to reenergize the hoisting machine until all emergency switching-off commands have been reset.

~~NOTE – Emergency stop and emergency switching-off are complementary protective measures that are not primary means of risk reduction for hazards (for example, crushing, impact, electric shock or burn) at a hoisting machine (see ISO 12100 (all parts)).~~

9.2.5.4.2 Emergency stop

Principles for the design of emergency stop equipment, including functional aspects, are given in ISO 13850:2015.

Hoisting machines shall have an emergency stop function, which shall at least stop the motion drives and other hoisting machine actuators that can cause hazardous condition(s). The emergency stop shall function either as a stop category 0 or as a stop category 1 (see 9.2.2). The choice of the stop category of the emergency stop depends on the results of a risk assessment of the hoisting machine.

Exception: In some cases, to avoid creating additional risks, it can be necessary to perform a controlled stop and maintain the power to machine actuators even after stopping is achieved. The stopped condition shall be monitored and upon detection of failure of the stopped condition, power shall be removed without creating a hazardous situation.

In addition to the requirements for stop (see 9.2.5.3), the emergency stop function has the following requirements.

- It shall override all other functions and operations in all modes.
- ~~– Power to the hoisting machine actuators that can cause a hazardous condition(s) shall be either removed immediately (stop category 0) or shall be controlled in such a way as to stop the hazardous motion as quickly as possible (stop category 1) without creating other hazards.~~
- It shall stop the hazardous motion as quickly as practicable without creating other hazards.
- Reset shall not initiate a restart.

The emergency stop function may be performed by one or more of the switching devices shown in Figure 3 (i.e. switchgear for drives, crane-switch or crane-supply-switch).

9.2.5.4.3 Emergency switching-off

The functional aspects of emergency switching-off are given in 536.4 of IEC 60364-5-53:2019.

Emergency switching-off should be provided where

- basic protection ~~against direct contact~~ (for example with conductor wires, conductor bars, slip-ring assemblies, controlgear in electrical operating areas) is achieved only by placing out of reach or by obstacles (see 6.2.6); or
- there is the possibility of other hazards or damage caused by electricity.

Emergency switching-off is accomplished by switching off the relevant incoming supply by electromechanical switching devices (e.g. by the crane-supply-switch), effecting a stop category 0 of hoisting machine actuators connected to this incoming supply. When a hoisting machine cannot tolerate this stop category 0 stop, it ~~can~~ may be necessary to provide other measures,

for example, by basic protection ~~against direct contact~~, so that emergency switching-off is not necessary (e.g. load-holding devices like magnets and vacuum lifters may require continuous power supply).

9.2.5.5 Monitoring of command actions

Movement or action of a hoisting machine or part of a hoisting machine that can result in a hazardous situation shall be monitored. On manually controlled hoisting machines, operators can provide some of this monitoring. Conditions that cannot reasonably be expected to be monitored by the operator will require means which may include over-travel limiters, motor over-speed detection, mechanical overload detection or anti-collision devices.

9.2.6 Other control functions

9.2.6.1 Hold-to-run controls

Hold-to-run controls shall require continuous actuation of the control device(s) to achieve operation.

NOTE Hold-to-run control can be accomplished, for example, by two-hand control devices.

9.2.6.2 Two-hand control

Three types of two-hand control are defined in ISO 13851, the selection of which is determined by the risk assessment.

9.2.6.3 Enabling control

Enabling control (see also 10.9) is a manually activated control function interlock that,

- a) when activated allows a hoisting machine operation to be initiated by a separate start control; and
- b) when de-activated
 - 1) initiates a stop function ~~of stop category 0 or 1~~, and
 - 2) prevents initiation of hoisting machine operation.

Enabling control shall be so arranged as to minimize the possibility of defeating, for example, by requiring the de-activation of the enabling control device before hoisting machine operation may be reinitiated. It should not be possible to defeat the enabling function by simple means.

The selection of the type of the enabling control device shall be made according to a risk assessment.

NOTE A three position type control device ~~may~~ can have advantage in case of cramp or panic.

9.2.6.4 Combined start and stop controls

Push-buttons and similar control devices that, when operated, alternately initiate and stop motion shall only be provided for functions which cannot result in a hazardous situation.

9.2.7 Cableless control system (CCS) 24

9.2.7.1 General requirements

~~This subclause deals with the functional requirements of control systems employing cableless (for example, radio, infra-red) techniques for transmitting commands and signals between a hoisting machine control system and operator control station(s) (see Clause 10, in particular see 10.1.5).~~

~~NOTE 1 The operator control station of a cableless control is usually called the transmitter and the part mounted on the hoisting machine is called the receiver. The receiver forms the interface to the control system of the hoisting machine.~~

~~NOTE 2 Some of these application and system considerations can also be applicable to control functions employing serial data communication techniques where the communications link uses a cable (for example, coaxial, twisted pair, optical fibre).~~

~~Means shall be provided to readily remove or disconnect the power supply of the operator control station (see also 9.2.7.3).~~

~~Means (for example, key-operated switch, access code) shall be provided, as necessary, to prevent unauthorized use of the cableless operator control station. The operator control station shall not transmit whilst the means to prevent unauthorized use is activated.~~

~~Each cableless operator control station shall carry an unambiguous indication of which hoisting machine(s) is intended to be controlled by that operator control station.~~

This 9.2.7 deals with the functional requirements and interfacing of control systems employing cableless techniques for transmitting commands and signals between a hoisting machine control system and operator control station(s) (see Clause 10, in particular see 10.1.5).

Transmission reliability requirements can be necessary for safety functions of a CCS that rely on data transmission (for example, safety-related active stop motion commands).

Further requirements for cableless control systems are given in IEC 62745:2017.

9.2.7.2 Control limitation

Measures shall be taken to ensure that control commands

- ~~— affect only the intended hoisting machine;~~
- ~~— affect only the intended functions;~~

~~Measures shall be taken to prevent the hoisting machine from responding to signals other than those from the intended operator control station(s).~~

~~The following control functions shall be included in the cableless control system.~~

- ~~— Activation of the cableless operator control station shall be indicated on the operator control station and shall not initiate any hoisting machine movement.~~
- ~~— The receiver shall provide operating commands to the control system of the hoisting machine only when it is receiving from the operator control station frames containing the right address and correct command.~~
- ~~— Unless otherwise stated in a dedicated product standard, the crane switch shall only be energized (i.e., controlled to the “on” state) and the stop function reset when the receiver has received from the operator control station at least one correct frame without any operating commands but containing a start command.~~
- ~~— To avoid inadvertent movements after any situation having caused the hoisting machine to stop (for example, power supply fault, battery replacement or lost signal condition), the receiver shall only output operating commands resulting in any hoisting machine movement after the hoisting machine driver has returned the actuators of the operator control station to “off” position for a suitable period of time (i.e., the receiver has received at least one frame without any operating commands).~~
- ~~— Whenever the crane switch is de-energized, all operating command outputs for hoisting machine movements shall be prevented.~~

~~Where necessary, means shall be provided so that the hoisting machine can only be controlled from operator control stations in one or more predetermined zones or locations.~~

9.2.7.2 Stop

~~Operator control stations shall include a separate and clearly identifiable means to initiate the stop function of the hoisting machine or of all the operations that can cause a hazardous situation. The actuating means to initiate this stop function shall not be marked or labelled as an emergency stop device. The stop may be stop category 0 or stop category 1, as determined by the risk assessment. It shall override all other functions and operations in all modes and the reset of this stop function shall not initiate a restart.~~

~~The part of the cableless control system to perform the stop function is a safety-related part of the hoisting machine control system and shall be designed so that a single fault in any of the parts does not lead to the loss of the safety function. Whenever reasonably practicable, the single fault shall be detected at, or before, the next demand upon the safety function.~~

~~NOTE — The feasibility of incorporating emergency stop devices in cableless control stations is under consideration in IEC/TC44.~~

~~The response time of a cableless control system shall not exceed 550 ms for a stop command.~~

~~A cableless control system shall automatically initiate the stopping of the hoisting machine by de-energizing the crane switch in the following situations:~~

- ~~— when a fault is detected in the cableless control system;~~
- ~~— when a valid signal has not been detected for a period of 0,5 s (see Annex B), except when a hoisting machine is executing a pre-programmed task taking it outside the range of the cableless control where no hazardous situation can occur. For those applications where 0,5 s is too short, this value may be extended up to a maximum of 2 s. The foreseen usage of the hoisting machine shall be evaluated to ensure that additional risks do not result from this extension of the time value. The de-energizing of the crane switch may be delayed for a maximum of 5 min provided that the initiation of stopping is assured by monitoring the state of the control system.~~

Requirements for stop functions are given in 4.7 of IEC 62745:2017.

The response time of the stop function shall not exceed 550 ms after a stop command has been initiated.

A cableless control system (CCS) shall automatically initiate the stopping of the hoisting machine by de-energizing the crane-switch according to IEC 62745:2017, 4.7.3.5 (automatic stop function ATS).

Exceptions:

For those applications where 550 ms is too short, this value may be extended up to a maximum of 2 s. The foreseen usage of the hoisting machine shall be evaluated to ensure that additional risks do not result from this extension of the time value. If the CCS is not able to regain the control of the hoisting machine, the de-energizing of the crane-switch may be delayed for a maximum of 5 min provided that the initiation of stopping is assured by monitoring the state of the control system.

Every CCS shall be equipped at least with a GSS (general safe stop) in accordance with IEC 62745:2017.

9.2.7.4 ~~Communication between the transmitter and the receiver~~

~~Frames shall be sent repeatedly during operation. Any frame requiring a motion to be initiated shall be correctly received before the control system can initiate that motion. Each transmitted frame shall include the required states of all commands.~~

~~The system shall provide a transmission reliability equal to a hamming distance of the total number of bits in a frame divided by 20 and at least 4, or other means which ensure an equal level of reliability such that the probability of an erroneous frame getting through is less than 10^{-8} .~~

~~NOTE Error detection methods in accordance with IEC 60870-5-1 are recommended.~~

9.2.7.5 Use of more than one operator control station

~~NOTE This subclause does not consider switching between hardwired and cableless control stations.~~

~~Where a hoisting machine has more than one cableless control station, measures shall be provided to ensure that only one of the control stations can be enabled at a given time. An indication of which operator control station is in control of the hoisting machine shall be provided at suitable locations as determined by the risk assessment of the hoisting machine.~~

~~Transferral of control from one transmitter to another shall not be possible until a stop signal for the crane motions has been transmitted and the first transmitter has been de-activated. The activation of the other transmitter shall require a deliberate action, specifically designed for this purpose.~~

~~Means shall be provided to enable several transmitter/receiver pairs to operate in the transmission range without unwanted interference with each other. These means shall be protected from accidental or unintentional change.~~

9.2.7.6 Battery powered operator control stations

~~A variation in the battery voltage shall not cause a hazardous situation. If one or more potentially hazardous motions are controlled using a battery powered cableless operator control station, a clear warning shall be given to the operator when a variation in battery voltage exceeds specified limits. Under those circumstances, the cableless operator control station shall remain functional long enough for the operator to put the hoisting machine into a non-hazardous situation.~~

~~NOTE A time period of 10 min is normally acceptable.~~

~~When the transmitter battery voltage becomes so low that a reliable transmission cannot be guaranteed, the transmitter shall initiate a stop signal in accordance with 9.2.7.3 and shall not transmit further frames until the transmitter is re-activated (see 9.2.7.2).~~

9.2.7.3 Use of multiple operator control stations

~~NOTE This 9.2.7.3 does not consider switching between hardwired and cableless control stations.~~

~~See 4.12 and 4.13 of IEC 62745:2017.~~

9.3 Protective interlocks

~~NOTE 1 Information on the safety related aspects of protective interlock control functions, including those implemented using programmable electronic systems, is given in ISO 12100-2:2003, ISO 13849-1:2006, ISO 13849-2:2003, and IEC 62061. See also 9.4.~~

~~NOTE 2 This subclause does not specify requirements for the equipment used to implement protective interlock control functions. Examples of such requirements are given in Clause 10.~~

9.3.1 General

~~Subclauses 9.3.2 to 9.3.6 do not specify requirements for the equipment used to implement protective interlock control functions. Examples of such requirements are given in Clause 10.~~

9.3.2 Reclosing or resetting of an interlocking safeguard

The reclosing or resetting of an interlocking safeguard shall not initiate hazardous hoisting machine motion or other operation.

NOTE Requirements for interlocking guards with a start function (control guards) are given in ~~5.3.2.5 of ISO 12100-2~~ 6.3.3.2.5 of ISO 12100:2010.

9.3.3 Exceeding operating limits

Where an operating limit (e.g. load, position, speed, pressure) can be exceeded leading to a hazardous situation, means (e.g. a position sensor or a limit switch) shall be provided to detect when a predetermined limit(s) is exceeded and initiate an appropriate control action determined by the risk assessment of the hoisting machine.

~~When a limiting device has initiated the stopping of the motion of a operator controlled hoisting machine, a restart shall be possible, but only in the opposite direction.~~

When a position limiting device has initiated the stopping function, a motion shall be possible only in the opposite direction.

9.3.4 Operation of auxiliary functions

The correct operation of auxiliary functions shall be checked by appropriate devices (e.g. pressure sensors).

Where the non-operation of a motor or device for an auxiliary function (e.g. lubrication, supply of coolant) can cause a hazardous condition or damage to the hoisting machine or to the load, appropriate interlocking shall be provided.

9.3.5 Interlocks between different operations and for contrary motions

All contactors, relays, and other control devices that control elements of the hoisting machine and that can cause a hazardous condition when actuated at the same time (e.g. those which initiate contrary motion), shall be interlocked against incorrect operation.

Reversing contactors (e.g. those controlling the direction of rotation of a motor) shall be interlocked in such a way that in normal service no short circuit can occur when switching.

Where, for safety or for continuous operation, certain functions on the hoisting machine are required to be interrelated, proper coordination shall be ensured by suitable interlocks. For a group of hoisting machines working together in a coordinated manner and having more than one controller, provision shall be made to coordinate the operations of the controllers as necessary.

Where a failure of a mechanical brake actuator can result in the brake being applied when the associated hoisting machine actuator is energized, and a hazardous condition can result, interlocks shall be provided to switch off the hoisting machine actuator.

When the hoisting machine actuator is not energized, and a hazardous condition can result if the mechanical brakes are released, interlocks shall be provided to disable release of the mechanical brakes.

9.3.6 Reverse current braking

Where reverse current braking is used on a motor, measures shall be taken to prevent the motor starting in the opposite direction at the end of braking where that reversal can cause a hazardous condition or damage to the hoisting machine or to the load. Devices operating exclusively as a function of time shall not be used for this purpose.

This requirement is only applicable on hoisting machines in automatic operation.

9.4 Control functions in the event of failure

9.4.1 General requirements **25**

Where failures or disturbances in the electrical equipment can cause a hazardous situation or damage to the hoisting machine or to the load, measures shall be taken to minimize the probability of the occurrence of such failures or disturbances. The required measures and the extent to which they are implemented, either individually or in combination, depend on the level of risk associated with the respective application (see 4.1).

~~The electrical control circuits shall have an appropriate level of safety performance that has been determined from the risk assessment at the hoisting machine. The requirements of IEC 62061 and/or ISO 13849-1:2006, ISO 13849-2:2003 shall apply.~~

~~Measures to reduce those risks include, but are not limited to,~~

- ~~— protective devices on the hoisting machine (for example, interlocking guards, trip devices);~~
- ~~— protective interlocking of the electrical circuit;~~
- ~~— use of proven circuit techniques and components (see 9.4.2.1);~~
- ~~— provision of partial or complete redundancy (see 9.4.2.2) or diversity (see 9.4.2.3);~~
- ~~— provision for functional tests (see 9.4.2.4).~~

Examples of such measures that can be appropriate include but are not limited to:

- protective interlocking of the electrical circuit;
- use of proven circuit techniques and components (see 9.4.2.2);
- provision of partial or complete redundancy (see 9.4.2.3) or diversity (see 9.4.2.4);
- provision for functional tests (see 9.4.2.5).

The electrical control system(s) shall have an appropriate performance that has been determined from the risk assessment of the machine.

The requirements for safety-related control functions of IEC 62061 and/or ISO 13849-1, ISO 13849-2 shall apply.

For non safety-related control functions basic safety principles of this document are applicable and adequate.

Where memory retention is achieved, for example, by battery power, measures shall be taken to prevent hazardous situations arising from failure, undervoltage or removal of the battery.

Means shall be provided to prevent unauthorized or inadvertent memory alteration by, for example, requiring the use of a key, access code or tool.

~~In general, only single failures are to be regarded. In high risk applications, it can be necessary to ensure that more than one failure cannot result in a hazardous condition.~~

9.4.2 Measures to minimize risk in the event of failure

9.4.2.1 General

Measures to minimize risk in the event of failure include but are not limited to:

- use of proven circuit techniques and components;
- provisions of partial or complete redundancy;

- provision of diversity;
- provision for functional tests.

9.4.2.2 Use of proven circuit techniques and components

These measures include, but are not limited to:

- bonding of control circuits to the protective bonding circuit for functional purposes (see 9.4.3.1 and Figure 4);
- connection of control devices in accordance with 9.4.3.1;
- stopping by de-energizing (see 9.2.2);
- switching of all control circuit conductors to the device being controlled (see 9.4.3.1);
- switching devices having direct opening action (see IEC 60947-5-1);
- monitoring by
 - use of mechanically linked contacts (see IEC 60947-5-1:2016),
 - use of mirror contacts (see IEC 60947-4-1:2018);
- circuit design to reduce the possibility of failures causing undesirable operations;
- using components (e.g. programmable electronic control systems) ~~with a proven~~ designed to reach a suitable specified performance level (see ISO 13849-1) or safety integrity level (see IEC 62061).

9.4.2.3 Provisions of partial or complete redundancy

By providing partial or complete redundancy, it is possible to minimize the probability that one single failure in the electrical circuit can result in a hazardous situation. Redundancy can be effective in normal operation (on-line redundancy) or designed as special circuits that take over the protective function (off-line redundancy) only where the operating function fails.

Where off-line redundancy which is not active during normal operation is provided, suitable measures shall be taken to ensure that those control circuits are available when required.

9.4.2.4 Provision of diversity

The use of control circuits having different principles of operation or using different types of components or devices can reduce the probability of hazards resulting from faults and/or failures. Examples include:

- the use of combination of normally open and normally closed contacts operated by interlocking guards;
- the use of different types of control ~~circuit components~~ devices in the circuit(s);
- the combination of electromechanical and electronic equipment in redundant configurations.

The combination of electrical and non-electrical systems (e.g. mechanical, hydraulic, pneumatic) can perform the redundant function and provide the diversity.

9.4.2.5 Provision for functional tests

~~Means shall be provided to carry out the necessary functional tests (see also 17.2 and 18.6)~~

- ~~— at start-up and/or at predetermined intervals;~~
- ~~— either automatically by the control system or manually (by inspection or testing) or a combination as appropriate.~~

Functional tests may be carried out automatically by the control system, or manually by inspection or tests at start-up and at predetermined intervals, or a combination as appropriate (see also 17.2 and 18.6).

~~9.4.3 Protection against mal-operation due to earth faults, voltage interruptions, and loss of circuit continuity~~

~~9.4.3.1 Earth faults~~

~~Earth faults on any control circuit shall not cause unintentional starting, potentially hazardous motions, or prevent stopping of the hoisting machine.~~

~~Methods to meet these requirements include, but are not limited to, the following:~~

~~Method a) Control circuits, fed by control transformers:~~

- ~~1) In the case of earthed control circuit supplies, the common conductor is connected to the protective bonding circuit. All contacts, solid state elements etc., which are intended to operate an electromagnetic or other device (for example, a relay, indicator light) are inserted between one side, the switched conductor of the control circuit supply and one terminal of the coil or device. The other terminal of the coil or device (preferably always having the same marking) is connected direct to the common conductor of the control circuit supply without any switching elements (see Figure 5).~~

~~Exception:~~ ~~Contacts of protective devices may be connected between the common conductor and the coils, provided that~~

- ~~— the circuit is interrupted automatically in the event of an earth fault;~~
- ~~— the connection is very short (for example, in the same enclosure) so that an earth fault is unlikely (for example, overload relays).~~

- ~~2) Control circuits fed from a control transformer and not connected to the protective bonding circuit, having the same arrangement as shown in Figure 5 and provided with an insulation monitoring device that interrupts the circuit automatically in the event of an earth fault (see also 7.2.4).~~

~~NOTE 1~~ ~~Indication of insulation failure may be used instead of interruption to put the hoisting machine into a safe condition.~~

~~Method b) Control circuits fed from a control transformer with a centre-tapped winding, this centre tap connected to the protective bonding circuit, arranged as shown in Figure 6 with the overcurrent protective device having switching elements in all control circuit supply conductors.~~

~~NOTE 2~~ ~~On a centre-tapped earthed control circuit, the presence of one earth fault can leave 50 % voltage on a relay coil. In this condition a relay can hold on, resulting in inability to stop a hoisting machine. In such a case it is necessary to switch coils or devices on both sides. In the case of detection of a single earth fault by an overcurrent device it is sufficient to switch coils and devices on one side only.~~

~~Method c) Where the control circuit is not fed from a control transformer and is either~~

- ~~1) connected direct between the phase conductors of an earthed supply;~~
- ~~2) connected direct between the phase conductors or between a phase conductor and a neutral conductor of a supply that is not earthed or is earthed through a high impedance,~~

~~multi-pole control switches that switch all live conductors are used for START or STOP of those hoisting machine functions that can cause a hazardous situation or damage to the hoisting machine in the event of unintentional starting or failure to stop, or in the case of c)2), an insulation monitoring device shall be provided that interrupts the circuit automatically in the event of an earth fault.~~

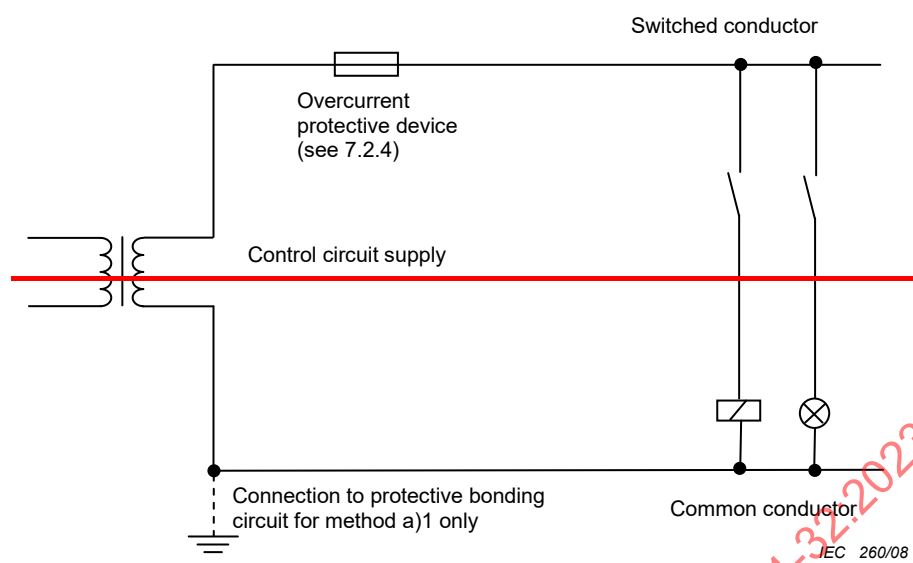


Figure 5 – Protection against mal-operation due to earth faults – Method a)

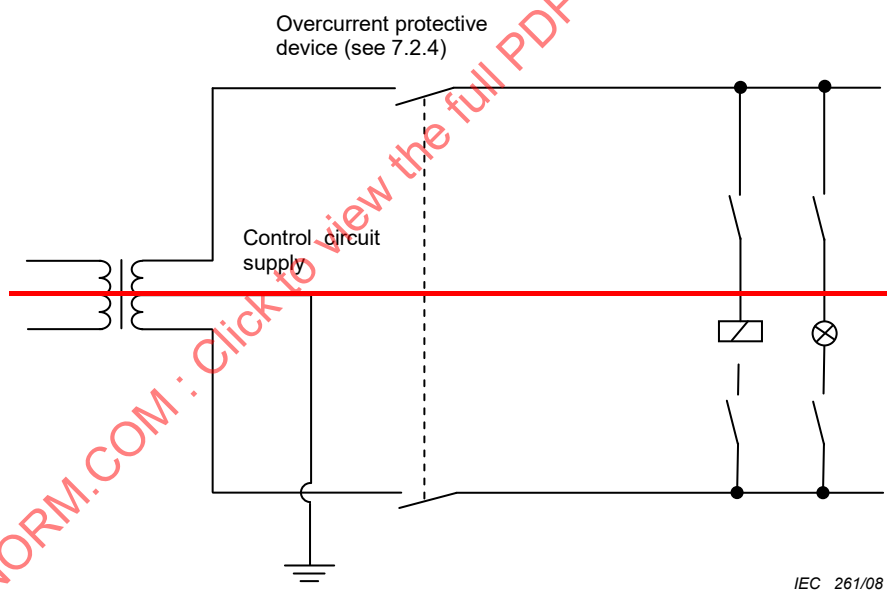


Figure 6 – Protection against mal-operation due to earth faults – Method b)

9.4.3 Protection against malfunction of control circuits 26

9.4.3.1 Insulation faults

9.4.3.1.1 General

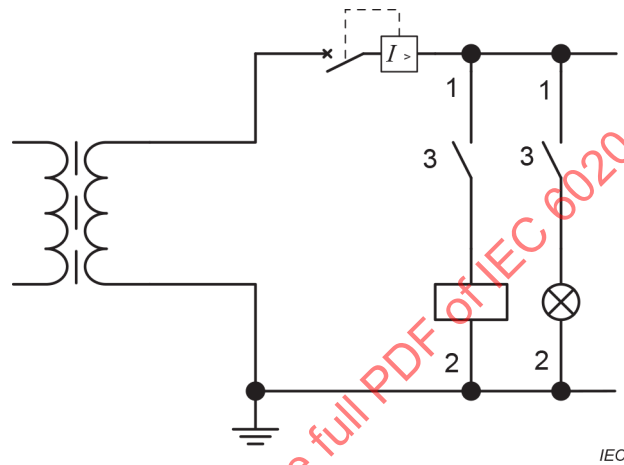
Measures shall be provided to reduce the probability that insulation faults on any control circuit can cause malfunction such as unintentional starting, potentially hazardous motions, or prevent stopping of the machine.

The measures to meet the requirements include but are not limited to the following methods:

- method a) Earthed control circuits fed by transformers;
- method b) Non-earthed control circuits fed by transformers;
- method c) Control circuits fed by transformer with an earthed centre-tap winding;
- method d) Control circuits not fed by a transformer.

9.4.3.1.2 Method a) Earthed control circuits fed by transformers

The common conductor shall be connected to the protective bonding circuit at the point of supply. All contacts, solid state elements, etc., which are intended to operate an electromagnetic or other device (for example, a relay, indicator light) are to be inserted between the switched conductor of the control circuit supply and one terminal of the coil or device. The other terminal of the coil or device is connected directly to the common conductor of the control circuit supply without any switching elements (see Figure 9).



- 1 Switched conductors
- 2 Common conductors
- 3 Control switches

Figure 9 – Method a) Earthed control circuit fed by a transformer

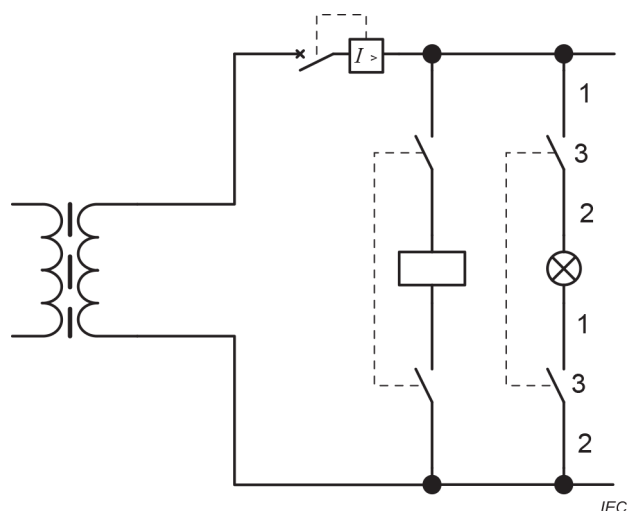
NOTE Method a) can be used also for DC control circuits. In this case the transformer shown in Figure 9 is substituted by a DC power supply unit.

Exception: Contacts or protective devices may be connected between the common conductor and the coils, provided that the connection is very short (for example in the same enclosure) so that an earth fault is unlikely (for example overload relays directly fitted to contactors).

9.4.3.1.3 Method b) Non-earthed control circuits fed by transformers

Control circuits fed from a control transformer that is not connected to the protective bonding circuit shall either:

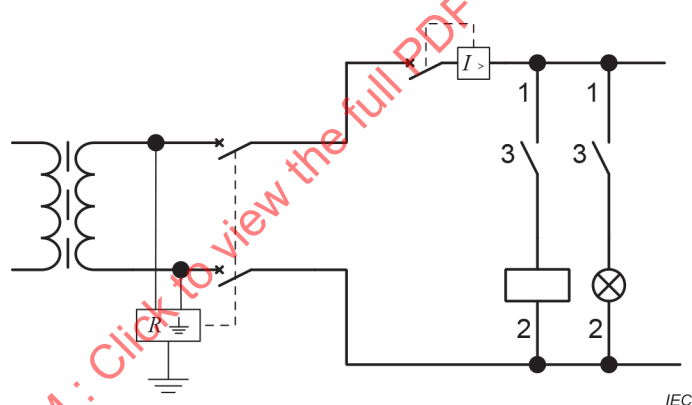
- b1) have 2-pole control switches that operate on both conductors, see Figure 10; or
- b2) be provided with a device, for example an insulation monitoring device, that interrupts the circuit automatically in the event of an earth fault, see Figure 11; or
- b3) where an interruption as per item b2) above would increase the risk, for example when continued operation is required during the first fault to earth, it can be sufficient to provide an insulation monitoring device (e.g. in accordance with IEC 61557-8:2014) that will initiate an acoustic and optical signal at the machine, see Figure 12. Requirements for the procedure to be performed by the machine user in response to this alarm shall be described in the information for use.



- 1 Switched conductors
- 2 Common conductors
- 3 Control switches

Figure 10 – Method b1) Non-earthed control circuit fed by transformer

NOTE 1 Method b1) can be used also for DC control circuits. In this case the transformer shown in Figure 10 is substituted by a DC power supply.

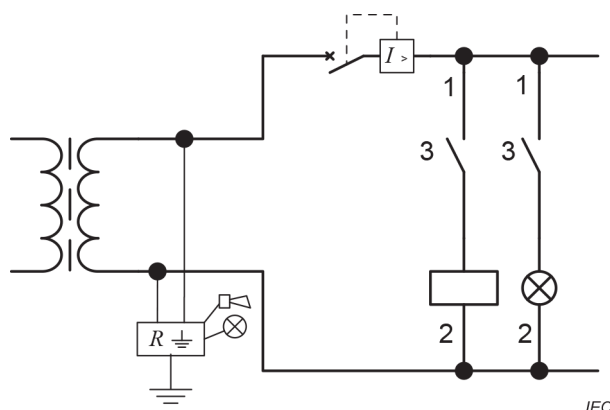


- 1 Switched conductors
- 2 Common conductors
- 3 Control switches

Figure 11 – Method b2) Non-earthed control circuit fed by transformer

NOTE 2 Method b2) can be used also for DC control circuits. In this case the transformer shown in Figure 11 is substituted by a DC power supply.

NOTE 3 Figure 11 does not show the overcurrent protective devices in the measurement circuits for protection of the insulation monitoring device.



- 1 Switched conductors
- 2 Common conductors
- 3 Control switches

Figure 12 – Method b3) Non-earthed control circuit fed by transformer

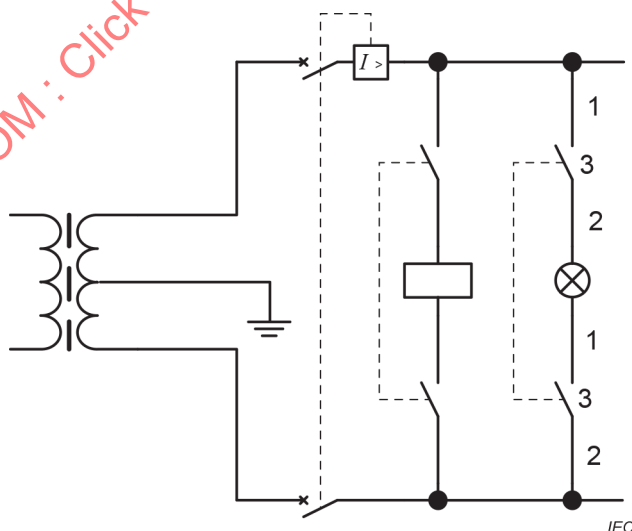
NOTE 4 Method b3) can be used also for DC control circuits. In this case the transformer shown in Figure 12 is substituted by a DC power supply. When a transformer and rectifier combination is used, the insulation monitoring device is connected to the protective bonding circuit in the DC part of the control circuit, so after the rectifier.

NOTE 5 Figure 12 does not show the overcurrent protective devices in the measurement circuits for protection of the insulation monitoring device.

9.4.3.1.4 Method c) Control circuits fed by transformer with an earthed centre-tap winding

Control circuits fed from a control transformer with its centre-tap winding connected to the protective bonding circuit shall have overcurrent protective devices that break both the conductors.

The control switches shall be 2-pole types that operate on both conductors.



- 1 Switched conductors
- 2 Common conductors
- 3 Control switches

Figure 13 – Method c) Control circuits fed by transformer with an earthed centre-tap winding

9.4.3.1.5 Method d) Control circuits not fed by a transformer

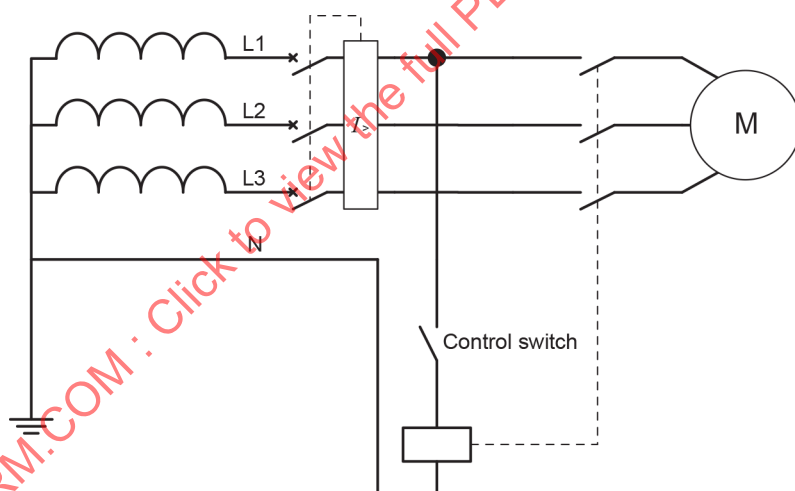
Control circuits that are not fed by a control transformer or switch mode power supply units fitted with transformers having separate windings in accordance with IEC 61558-2-16 are only allowed for machines with a maximum of one motor starter and/or maximum of two control devices, in accordance with 9.1.2.

Depending on the earthing of the supply system the possible cases are:

- d1) directly connected to an earthed supply system (TN- or TT-system) and:
 - d1a) being powered between a line conductor and the neutral conductor, see Figure 14; or
 - d1b) being powered between two line conductors, see Figure 15; or
- d2) directly connected to a supply system that is not earthed or is earthed through a high impedance (IT-system) and:
 - d2a) being powered between a line conductor and the neutral conductor, see Figure 16; or
 - d2b) being powered between two line conductors, see Figure 17.

Method d1b) requires multi-pole control switches that switch all live conductors in order to avoid an unintentional start in case of an earth fault in the control circuit.

Method d2) requires that a device shall be provided that interrupts the circuit automatically in the event of an earth fault.



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Figure 14 – Method d1a) Control circuit without transformer connected between a phase and the neutral of an earthed supply system

NOTE 1 Figure 14 shows the case where the supply system is a TN system. The control circuit is the same in the case of a TT system.

NOTE 2 Figure 14 does not show any protective devices for the power circuit and control circuit, provisions for which are stated in 6.3 and 7.2.

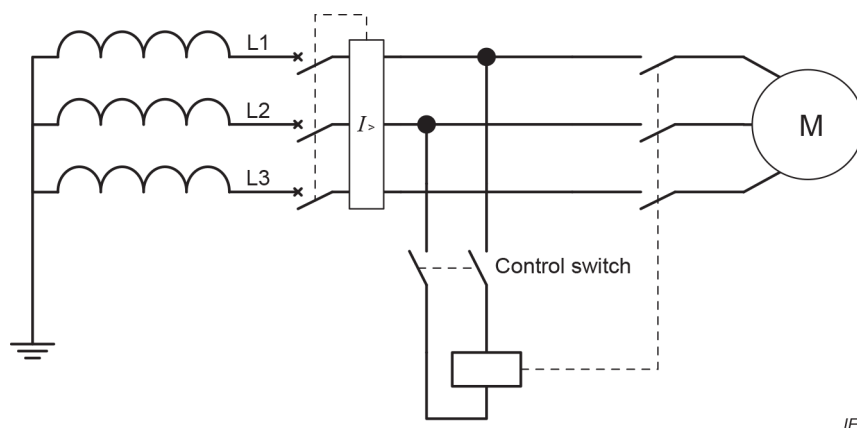


Figure 15 – Method d1b) control circuit without transformer connected between two phases of an earthed supply system

NOTE 3 Figure 15 shows the case where the supply system is a TN system. The control circuit is the same in case of a TT system.

NOTE 4 Figure 15 does not show any necessary protective devices for power circuit and control circuit, provisions for which are stated in 6.3 and 7.2.

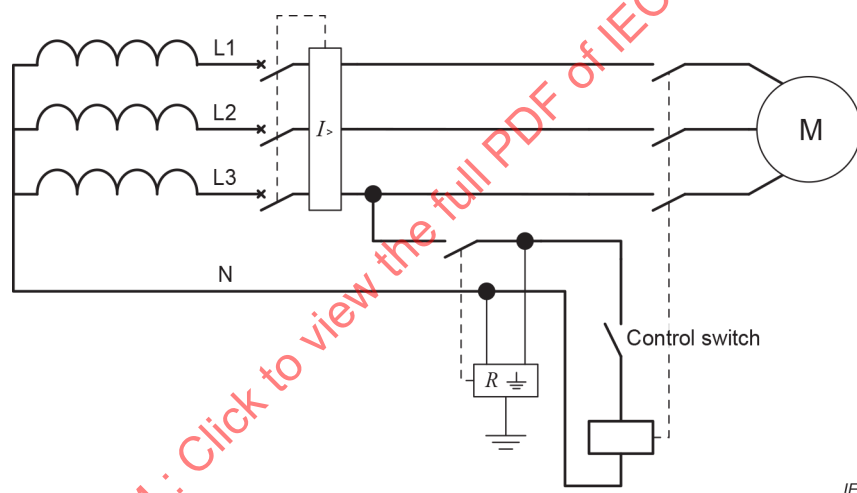


Figure 16 – Method d2a) Control circuit without transformer connected between phase and neutral of a non-earthed supply system

NOTE 5 Figure 16 does not show any necessary protective devices for the power circuit and control circuit, provisions for which are stated in 6.3 and 7.2.

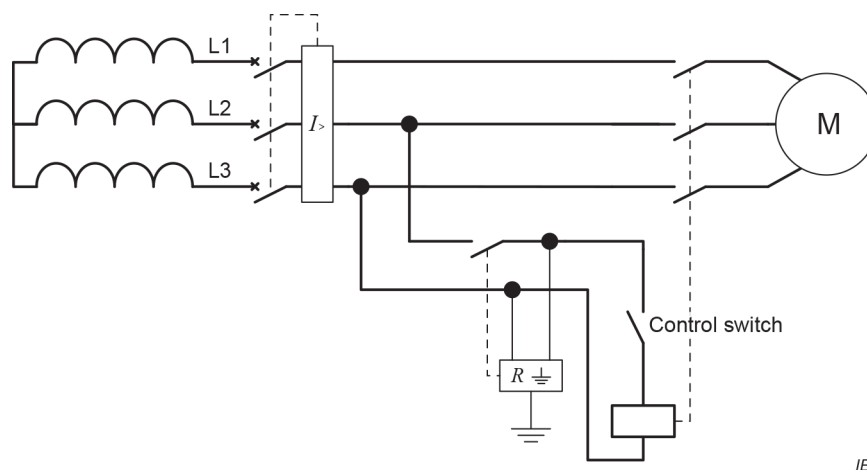


Figure 17 – Method d2b) control circuit without transformer connected between two phases of a non-earthed supply system

NOTE 6 Figure 17 does not show any necessary protective devices for power circuit and control circuit, provisions for which are stated in 6.3 and 7.2.

9.4.3.2 Voltage interruptions

~~The requirements detailed in 7.5 shall apply.~~

See also 7.5.

Where the control system uses a memory device(s), proper functioning in the event of power failure shall be ensured (for example by using a non-volatile memory) to prevent any loss of memory that can result in a hazardous situation.

9.4.3.3 Loss of circuit continuity

Where the loss of continuity of ~~safety-related~~ control circuits depending upon sliding contacts can result in a hazardous situation, appropriate measures shall be taken (for example by duplication of the sliding contacts).

9.4.4 Protection against maloperation of a motion control system

In a motion control system for an electric motor(s), inadmissible control deviations which can cause a hazardous condition shall be detected automatically, the power to the motor(s) shall be switched off by a category 0 stop, and the mechanical brake system shall be applied ~~(see 14.7)~~.

In a hydraulic or pneumatic drive employing an energy converter, the motion shall be stopped if the electrical supply to the energy converter fails.

Triggering of any internal protective function of any component of the motion control system (e.g. overvoltage or overcurrent protection of adjustable speed drives, which are designed to protect the device itself) shall not cause loss of control of the motion nor uncontrolled motions.

10 Operator interface and hoisting machine mounted control devices

10.1 General

10.1.1 General ~~device~~ requirements

This Clause 10 contains requirements for devices mounted outside or partially outside of control enclosures.

~~As far as is practicable, those devices shall be selected, mounted, and identified or coded in accordance with relevant parts of IEC 61310.~~

Control devices for operator interface shall, as far as is practicable, be selected, mounted, and identified or coded in accordance with IEC 61310 (all parts).

The possibility of inadvertent operation shall be minimized by, for example, positioning of devices, suitable design, provision of additional protective measures. Particular consideration shall be given to the selection, arrangement, programming and use of operator input devices such as touch screens, keypads and keyboards, for the control of hazardous hoisting machine operations, and of sensors (for example position sensors) that can initiate machine operation. Further information can be found in IEC 60447:2004.

Hand-held direct-control devices are permitted only for hoisting machines operating at rated values not exceeding 500 V AC and 7,5 kW. They shall be protected ~~against indirect contact~~ by fault protection in accordance with 6.3.2.2 (see also 9.4.2).

Ergonomic principles shall be taken into account in the location of operator interface devices.

10.1.2 Location and mounting

As far as is practicable, hoisting machine-mounted control devices shall be

- readily accessible for service and maintenance;
- mounted in such a manner as to minimize the possibility of damage from activities such as material handling.

The actuators of hand-operated control devices shall be selected and installed so that

- they are not less than 0,6 m above the servicing level and are within easy reach of the normal working position of the operator;
- the operator is not placed in a hazardous situation when operating them.

The actuators of foot-operated control devices shall be selected and installed so that

- they are within easy reach of the normal working position of the operator;
- the operator is not placed in a hazardous situation when operating them.

10.1.3 Protection

The degree of protection ~~(see in accordance with IEC 60529 (IP rating))~~ together with other appropriate measures shall ~~afford~~ provide protection against

- the effects of ~~aggressive~~ liquids, vapours, or gases found in the physical environment or used on the hoisting machine;
- the ingress of contaminants (e.g. dust, particulate matter).

In addition, the operator interface control devices shall have a minimum degree of basic protection ~~against direct contact~~ of IPXXD (see IEC 60529).

10.1.4 Position sensors

Position sensors (e.g. position switches, proximity switches) shall be so arranged that they will not be damaged in the event of over-travel.

Position sensors in circuits with safety-related control functions (for example, to maintain the safe condition of the hoisting machine or prevent hazardous situations arising at the hoisting machine) shall have direct opening action (see IEC 60947-5-1:2016) or shall provide similar reliability (see 9.4.2).

~~NOTE—A safety-related control function is intended to maintain the safe condition of the hoisting machine or prevent hazardous situations arising at the hoisting machine.~~

10.1.5 Portable and pendant control stations

Portable and pendant operator control stations and their control devices shall be so selected and arranged as to minimize the possibility of ~~inadvertent~~ hoisting machine operations caused by ~~inadvertent~~ actuation, shocks and vibrations (e.g. if the operator control station is dropped or strikes an obstruction) (see also 4.4.8).

Portable operation control stations (equipment) shall:

- be provided with means to reduce the probability of accidental dropping, for example a belt or neck strap;
- meet the following tests without visible damage or incorrect operation:
 - free fall test in accordance with ~~IEC 60068-2-32:2008, Test Ed~~ IEC 60068-2-31:2008, Test Ec;
 - shock test in accordance with IEC 60068-2-27:2008, Test Ea.

10.2 ~~Push-buttons~~ Actuators

10.2.1 Colours

~~Push-button actuators shall be colour-coded in accordance with Table 2 (see also 9.2 and Annex B).~~

Actuators (see 3.1.1) are colour-coded as follows.

The colours for START/ON actuators should be WHITE, GREY, BLACK or GREEN with a preference for WHITE. RED shall not be used.

The colour RED shall be used for emergency stop and emergency switching-off actuators (including supply disconnecting devices where it is foreseen that they are for use in an emergency). If a background exists immediately around the actuator, then this background shall be coloured YELLOW. The combination of a RED actuator with a YELLOW background shall only be used for emergency operation devices.

The colours for STOP/OFF actuators should be BLACK, GREY, or WHITE with a preference for BLACK. GREEN shall not be used. RED is permitted, but it is recommended that RED is not used near an emergency operation device.

WHITE, GREY, or BLACK are the preferred colours for ~~push-button~~ actuators that alternately act as START/ON and STOP/OFF ~~push-buttons~~ actuators. The colours RED, YELLOW, or GREEN shall not be used ~~(see also 9.2.6).~~

WHITE, GREY, or BLACK are the preferred colours for ~~push-button~~ actuators that cause operation while they are actuated and cease the operation when they are released (for example hold-to-run). The colours RED, YELLOW, or GREEN shall not be used.

Reset ~~push-buttons~~ actuators shall be BLUE, WHITE, GREY, or BLACK. Where they also act as a STOP/OFF ~~button~~ actuator, the colours WHITE, GREY, or BLACK are preferred with the main preference being for BLACK. GREEN shall not be used.

The colour YELLOW is reserved for use in abnormal conditions, for example, in the event of an abnormal condition of the process, or to interrupt an automatic cycle.

Where the same colour WHITE, GREY, or BLACK is used for various functions (for example WHITE for START/ON and for STOP/OFF actuators) a supplementary means of coding (for example shape, position, symbol) shall be used for the identification of ~~push-button~~ actuators.

Table 2 – Colour-coding for push-button actuators and their meanings 27

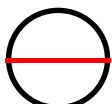
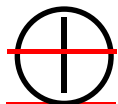
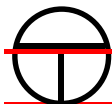
Colour	Meaning	Explanation	Examples of application
RED	Emergency	Actuate in the event of a hazardous situation or emergency	Emergency stop Initiation of emergency function
YELLOW	Abnormal	Actuate in the event of an abnormal condition	Intervention to suppress abnormal condition Intervention to restart an interrupted automatic cycle
BLUE	Mandatory	Actuate for a condition requiring mandatory action	Reset function
GREEN	Normal	Actuate to initiate normal conditions	
WHITE	No specific meaning assigned	For general initiation of functions except for emergency stop (see note)	START/ON (preferred) STOP/OFF
GREY			START/ON STOP/OFF
BLACK			START/ON STOP/OFF (preferred)

NOTE Where a supplementary means of coding (for example, shape, position, texture) is used for the identification of push-button actuators, then the same colour WHITE, GREY, or BLACK may be used for various functions (for example, WHITE for START/ON and for STOP/OFF actuators).

10.2.2 Markings

In addition to the functional identification as described in 16.3, it is recommended that push-buttons be marked, near to or preferably direct on the actuators, with the symbols shown in Table 3.

Table 3 – Symbols for push-buttons

START or ON	STOP or OFF	Push-buttons acting alternately as START or STOP buttons and as ON or OFF buttons	Push-buttons acting as START or ON buttons when pressed and as STOP or OFF buttons when released (i.e. hold-to-run)
IEC 60417-5007 (2002-10) 	IEC 60417-5008 (2002-10) 	IEC 60417-5010 (2002-10) 	IEC 60417-5011 (2002-10) 

In addition to the functional identification as described in 16.3, recommended symbols to be placed near to or preferably directly on certain actuators are given in Table 2 and Table 3.

Table 2 – Symbols for actuators (power)

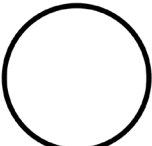
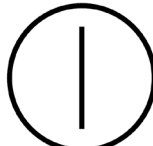
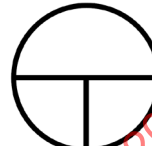
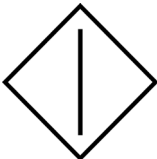
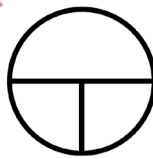
Power			
ON	OFF	ON/OFF (push on-push off)	ON (hold-to-run)
IEC 60417-5007 (2002-10)	IEC 60417-5008 (2002-10)	IEC 60417-5010 (2002-10)	IEC 60417-5011 (2002-10)
			

Table 3 – Symbols for actuators (machine operation)

Machine operation			
START	STOP	HOLD-TO-RUN	EMERGENCY STOP
IEC 60417-5104 (2006-08)	IEC 60417-5110A (2004-06)	IEC 60417-5011 (2002-10)	IEC 60417-5638 (2002-10)
			

10.3 Indicator lights, displays and audible devices

10.3.1 General

Indicator lights and displays serve to give the following types of information.

- Indication: to attract the operator's attention or to indicate that a certain task should be performed. The colours RED, YELLOW, BLUE, and GREEN are normally used in this mode; for flashing indicator lights and displays, see 10.3.3.
- Confirmation: to confirm a command, or a condition, or to confirm the termination of a change or transition period. The colours BLUE and WHITE are normally used in this mode and GREEN may be used in some cases.

Indicator lights and displays shall be selected and installed in such a manner as to be visible from the normal position of the operator (see also IEC 61310-1).

~~Indicator light circuits used for warning lights shall be fitted with facilities to check the operability of these lights.~~

Circuits used for visual or audible devices used to warn persons of an impending hazardous event shall be fitted with facilities to check the operability of these devices.

10.3.2 Colours

~~Unless otherwise agreed between the supplier and the user (see Annex B),~~ Indicator lights shall be colour-coded with respect to the condition (status) of the hoisting machine in accordance with Table 4.

Table 4 – Colours for indicator lights and their meanings with respect to the condition of the hoisting machine

Colour	Meaning	Explanation	Action by operator
RED	Emergency	Hazardous condition	Immediate action to deal with hazardous condition (e.g. switching off the hoisting machine supply, being alert to the hazardous condition)
YELLOW	Abnormal	Abnormal condition Impending critical condition	Monitoring and/or intervention (e.g. by re-establishing the intended function)
BLUE	Mandatory	Indication of a condition that requires action by the operator	Mandatory action
GREEN	Normal	Normal condition	Optional
WHITE	Neutral	Other conditions may be used whenever doubt exists about the application of RED, YELLOW, GREEN, BLUE	Monitoring

Indicating towers on hoisting machines ~~should~~ shall have the applicable colours in the following order from the top down ~~when used vertically~~: RED, YELLOW, BLUE, GREEN and WHITE.

10.3.3 Flashing lights and displays

For further distinction or information and especially to give additional emphasis, flashing lights and displays can be provided for the following purposes:

- to attract attention;
- to request immediate action;
- to indicate a discrepancy between the command and actual state;
- to indicate a change in process (flashing during transition).

It is recommended that higher frequency flashing lights or displays be used for higher priority information (see IEC 60073:2002 for recommended flashing rates and pulse/pause ratios).

Where flashing lights or displays are used to provide higher priority information, audible ~~warning devices~~ warnings should also be provided.

10.4 Illuminated push-buttons

Illuminated push-button actuators shall be colour-coded in accordance with ~~Tables 2 and 4~~ 10.2.1. Where there is difficulty in assigning an appropriate colour, WHITE shall be used. ~~The colour RED for the emergency stop actuator shall not depend on the illumination of its light.~~

The colour of active emergency stop actuators shall remain RED regardless of the state of the illumination.

10.5 Rotary control devices

Devices having a rotational member, such as potentiometers and selector switches, shall have means of prevention of rotation of the stationary member. Friction alone shall not be considered sufficient.

10.6 Start devices

Actuators used to initiate a start function or the movement of hoisting machine elements (e.g. trolleys) shall be constructed and mounted so as to minimize inadvertent operation. ~~However, mushroom type actuators may be used for two hand control (see also ISO 13851).~~

10.7 Emergency stop devices

10.7.1 Location of emergency stop devices

Devices for emergency stop shall be readily accessible.

~~Emergency stop devices shall be located at each operator control station and at other locations where the initiation of an emergency stop can be required, for example, near unprotected rope winches (exception: see 9.2.7.3).~~

~~Fixed (Non detachable) emergency stop devices shall be active all times, including when the corresponding operator control station is not active.~~

Emergency stop devices shall be provided: **28**

- at each operator control station; and
- at other locations where the initiation of an emergency stop can be required, based on risk assessment.

When emergency stop devices are installed on detachable or cableless operator control stations (e.g. pluggable portable teaching pendants), at least one emergency stop device shall be permanently available (e.g. in a fixed position) on the hoisting machine.

Where required, emergency stop devices shall also be located outside the hoisting machine (e.g. operable at floor level in the case of overhead travelling cranes).

Non detachable emergency stop devices shall be active all the time even if the corresponding operator control station is not active.

For detachable emergency stop devices (e.g. operator control stations as standby devices with plug and socket combination), means shall be provided to avoid confusion whether the emergency stop device is active or not (e.g. information for use, keeping inactive operator control stations under lock and key).

~~Where required, emergency stop devices shall also be located outside the hoisting machine (for example, operable at floor level in the case of overhead travelling cranes).~~

For emergency stop devices of CCS, see also IEC 62745:2017.

The stopping of all motion drives from floor level may be dispensed with for those drives of the hoisting machine which may cause additional hazards; for example, on gantry cranes it may be sufficient to stop the gantry motion. On mobile cranes such devices may not be required at floor level.

10.7.2 Types of emergency stop device

The types of device for emergency stop include, but are not limited to:

- a push-button operated switch with a palm or mushroom head type;
- a pull-cord operated switch;
- a pedal-operated switch without a mechanical guard.

~~The devices shall have direct opening operation (see IEC 60947-5-1, Annex K).~~

The devices shall be in accordance with IEC 60947-5-5.

10.7.3 Colour of actuators

Actuators of emergency stop devices shall be coloured RED. If a background exists immediately around the actuator, then this background shall be coloured YELLOW. See also ISO 13850:2015.

10.7.4 Local operation of the crane-supply-switch and the crane-disconnector to effect emergency stop

The crane-supply-switch and/or the crane-disconnector may be locally operated to serve the function of emergency stop when

- it is readily accessible to the operator; and
- it is of the type described in 5.3.2a), b), c), or d).

When also intended for such use, the crane-supply-switch and/or the crane-disconnector shall conform to the colour requirements of 10.7.3.

NOTE This device is usually not located at the operator control station and, therefore, it cannot be used as the only emergency stop device (see 10.7.1 and 10.8.1).

10.8 Emergency switching-off devices

10.8.1 Location of emergency switching-off devices

The device shall be capable of being operated from an easily and quickly accessible location near to the hoisting machine, either direct, or remotely. According to a risk assessment the provision of emergency switching-off facilities may also be necessary for other locations in which live conductors may be exposed in normal service (see also 9.2.5.4.3 and 12.7.1).

Normally, those devices will be located separate from operator control stations. ~~Where it is necessary to provide a control station with an emergency stop device and an emergency switching-off device, means shall be provided to avoid confusion between these devices.~~ Where confusion can occur between emergency stop and emergency switching-off devices, means shall be provided to minimize confusion.

NOTE This can be achieved by, for example, the provision of a break-glass enclosure for the emergency switching-off device.

10.8.2 Types of emergency switching-off device

The types of devices for initiation of emergency switching-off include

- a push-button operated switch with a palm or mushroom head type of actuator;
- a pull-cord operated switch.

The devices shall have direct opening action (see Annex K of IEC 60947-5-1:2016).

~~The push-button operated switch may be in a break-glass enclosure.~~

10.8.3 Colour of actuators

Actuators of emergency switching-off devices shall be coloured RED. If a background exists immediately around the actuator then this background shall be coloured YELLOW.

~~Where confusion can occur between emergency stop and emergency switching-off devices, means shall be provided to minimize confusion.~~

10.8.4 Local operation of the crane-supply-switch and the crane-disconnector to effect emergency switching-off

Where the crane-supply-switch or the crane-disconnector is to be locally operated for emergency switching-off, it shall be readily accessible and ~~should conform to~~ shall meet the colour requirements of 10.8.3.

The crane-disconnector shall have sufficient breaking capability if used for emergency switching-off.

10.9 Enabling control device

When an enabling control device is provided as a part of a system, it shall signal the enabling control to allow operation when actuated in one position only. In any other position, operation shall be stopped or prevented.

Enabling control devices shall be selected and arranged so as to minimize the possibility of defeating.

Enabling control devices shall be selected that have the following features.

- Designed in accordance with ergonomic principles.
- For a two-position type:
 - position 1: off-function of the switch (actuator is not operated);
 - position 2: enabling function (actuator is operated).
- For a three-position type:
 - position 1: off-function of the switch (actuator is not operated);
 - position 2: enabling function (actuator is operated in its mid position);
 - position 3: off-function (actuator is operated past its mid position);
 - when returning from position 3 to position 2, the enabling function is not activated.

NOTE 1 The enabling control function is described in 9.2.6.3.

NOTE 2 IEC 60947-5-8 specifies requirements for three-position enabling switches.

11 Controlgear: location, mounting and enclosures

11.1 General requirements

All controlgear shall be located and mounted so as to facilitate

- its accessibility and maintenance;
- its protection against the external influences or conditions under which it is intended to operate;
- operation and maintenance of the hoisting machine and its associated equipment.

11.2 Location and mounting

11.2.1 Accessibility and maintenance

All items of controlgear shall be placed and oriented so that they can be identified without moving them or the wiring. For items that require checking for correct operation or that are liable to need replacement, those actions should be possible without dismantling other equipment or

parts of the hoisting machine (except opening doors or removing covers, barriers or obstacles). Terminals not part of controlgear components or devices shall also conform to these requirements.

All controlgear shall be mounted so as to facilitate its operation and maintenance ~~from the front~~. Where a special tool is necessary to adjust, maintain, or remove a device, such a tool shall be supplied. Where access is required for regular maintenance or adjustment, the relevant devices shall be located between 0,4 m and 2,0 m above the servicing level. It is recommended that terminals be at least 0,2 m above the servicing level and be so placed that conductors and cables can be easily connected to them.

No devices except devices for operating, indicating, measuring, and cooling shall be mounted on doors or on normally removable access covers of enclosures. Where control devices are connected through plug-in arrangements, their association shall be made clear by type (shape), marking or reference designation, singly or in combination (see 13.4.5).

Plug-in devices that are handled during normal operation shall be provided with non-interchangeable features where the lack of such a facility can result in malfunctioning.

Plug/socket combinations that are handled during normal operation shall be located and mounted so as to provide unobstructed access.

Test points for connection of test equipment, where provided, shall be

- mounted so as to provide unobstructed access;
- clearly identified to correspond with the documentation ~~(see 17.3)~~;
- adequately insulated;
- sufficiently spaced.

11.2.2 Physical separation or grouping

Non-electrical parts and devices, not associated direct with the electrical equipment, shall not be located within enclosures containing controlgear. Devices such as solenoid valves should be separated from the other electrical equipment (e.g. in a separate compartment).

Control devices mounted in the same location and connected to the ~~supply voltage~~ power circuits, or to both ~~supply~~ power circuits and control ~~voltages~~ circuits, ~~shall~~ should be grouped separately from those connected only to the control ~~voltages~~ circuits.

Terminals shall be separated into groups for

- power circuits;
- associated control circuits of the hoisting machine;
- other control circuits, fed from external sources (e.g. for interlocking).

The groups may be mounted adjacently, provided that each group can be readily identified (e.g. by markings, by use of different sizes, by use of barriers or by colours).

When arranging the location of devices (including interconnections), the clearances and creepage distances specified for them by the supplier shall be maintained, taking into account the external influences or conditions of the physical environment.

11.2.3 Heating effects

The temperature inside electrical equipment enclosures shall not exceed the ambient temperature specified by the component manufacturers.

NOTE 1 IEC TR 60890 can be used for the calculation of temperature rise inside enclosures.

Heat generating components (e.g. heat sinks, power resistors) shall be so located that the temperature of each component in the vicinity remains within the permitted limit.

~~Accessible parts of electrical equipment shall comply with the appropriate limits stated in table 42A of IEC 60364-4-42. All parts likely to attain temperatures exceeding these limits, shall be guarded so as to prevent any accidental contact or marked in accordance with 16.2.2.~~

NOTE 2 Information on the selection of insulating materials to resist thermal stresses is given in IEC 60216 and IEC 60085.

Consideration shall be given to avoid excessive heating of the environment of the hoisting machine (e.g. braking resistors of adjustable speed drives can cause fire hazards in dusty environment or when the hoisting machine is parked adjacent to sensitive material).

~~NOTE For example, the (braking) resistors used with adjustable speed (a.c.) drives usually require either a warning sign or protective measures.~~

11.3 Degrees of protection

The protection of controlgear against ingress of solid foreign objects and of liquids shall be adequate taking into account the external influences under which the hoisting machine is intended to operate (i.e. the location and the physical environmental conditions) and shall be sufficient against dust, coolants, lubricants and swarf.

~~NOTE 1 Requirements for protection against electric shock are given in Clause 6.~~

~~NOTE 2~~ 1 The degrees of protection against ingress of water are covered by IEC 60529. Additional protective measures can be necessary against other liquids.

Enclosures of controlgear shall provide a degree of protection of at least ~~IP2X~~ IP22 (see IEC 60529).

Exceptions:

- ~~a) Where an electrical operating area is used as a protective enclosure for an appropriate degree of protection against the ingress of solid bodies and liquids.~~
- ~~b) Where removable collectors on conductor wire or conductor bar systems are used and IP2X is not achieved but the measures of 6.2.5 are applied.~~

Exception: an enclosure providing a minimum degree of protection IP22 is not required where

- a) an electrical operating area provides an appropriate degree of protection against ingress of solids and liquids, or
- b) removable collectors on conductor wire or conductor bar systems are used and the measures of 6.2.5 are applied.

NOTE 2 Some examples of applications, along with the degree of protection typically provided by their enclosures, are listed below.

~~Ventilated enclosure, containing only motor starter resistor and other large size equipment~~	~~IP10~~
~~Ventilated enclosure, containing other equipment~~	~~IP32~~
~~Enclosure used in general industry~~	~~IP32, IP43 and IP54~~
~~Enclosure used in locations that are cleaned with low pressure water jets (hosing)~~	~~IP55~~
~~Enclosure providing protection against fine dust~~	~~IP65~~
~~Enclosure containing slip ring assemblies~~	~~IP2X~~

– Ventilated enclosure, containing braking resistor or similar equipment	IP10
– Enclosure containing electrical equipment	IP32, IP43 and IP54
– Enclosure used in outdoor applications or locations that are cleaned with low-pressure water jets (hosing)	IP55
– Enclosure providing protection against fine dust	IP65
– Enclosure containing slip-ring assemblies	IP2X

Depending upon the conditions where installed, another degree of protection can be appropriate.

11.4 Enclosures, doors and openings

Enclosures shall be constructed using materials capable of withstanding the mechanical, electrical and thermal stresses as well as the effects of humidity and other environmental factors that are likely to be encountered in normal service.

~~Fasteners used to secure doors and covers should be of the captive type. Windows provided for viewing internally mounted indicating devices shall be of a material suitable to withstand mechanical stress and chemical attack (for example, toughened glass, polycarbonate sheet of not less than 3 mm thickness).~~

Windows of enclosures shall be of a material suitable to withstand expected mechanical stress and chemical attack.

It is recommended that enclosure doors are not wider than 0,9 m and have vertical hinges, with an angle of opening of at least 95°.

The joints or gaskets of doors, lids, covers and enclosures shall withstand the chemical effects of the aggressive liquids, vapours, or gases in the environment of the hoisting machine (see Annex B). The means provided to maintain the degree of protection of an enclosure on doors, lids and covers that require opening or removal for operation or maintenance shall

- be securely attached to either the door/cover or the enclosure;
- not deteriorate due to removal or replacement of the door or the cover and so impair the degree of protection.

Where openings in enclosures are provided (e.g. for cable access), including those towards the floor or foundation or to other parts of the hoisting machine, means shall be provided to ensure the degree of protection specified for the equipment. Openings for cable entries shall be easily re-opened on site. A suitable opening may be provided in the base of enclosures within the hoisting machine so that moisture due to condensation can drain away.

There shall be no opening between enclosures containing electrical equipment and compartments containing coolant, lubricating or hydraulic fluids, or those into which oil, other liquids, or dust can penetrate. This requirement does not apply to electrical devices specifically designed to operate in oil (e.g. electromagnetic clutches) nor to electrical equipment in which coolants are used.

Where there are holes in an enclosure for mounting purposes, means may be necessary to ensure that, after mounting, the holes do not impair the required protection.

Equipment that, in normal or abnormal operation, can attain a surface temperature sufficient to cause a risk of fire or ~~harmful~~ detrimental effect to an enclosure material

- shall be located within an enclosure that will withstand, without risk of fire or harmful effect, such temperatures as can be generated;
- shall be mounted and located at a sufficient distance from adjacent equipment so as to allow safe dissipation of heat (see also 11.2.3);
- shall be otherwise screened by material that can withstand, without risk of fire or harmful effect, the heat emitted by the equipment.

~~NOTE~~ A warning label in accordance with 16.2.2 ~~may~~ should be ~~necessary~~ applied.

11.5 Access to switchgear and to controlgear

11.5.1 General

Dimensions of operating and maintenance gangways in front of and between switchgear and controlgear shall be sufficient for safe operation and maintenance of electrical equipment. The minimum dimensions are defined in 11.5.2 and 11.5.3.

Depending on the risk assessment, the requirements set out in 11.5.2 and 11.5.3 do not apply to enclosures containing only terminals and other components which require minimal maintenance (e.g. resistors) ~~need not conform to this subclause~~.

NOTE Further information is given in IEC 60364-7-729.

11.5.2 Access to gangways

Operating and maintenance gangways of a length of 20 m and longer shall be accessible from both ends. For gangways shorter than 20 m, but exceeding ~~6~~ 10 m, access from both ends is recommended.

Doors in gangways and for access to electrical operating areas which readily allow a person to fully enter shall

- be at least 0,7 m wide and 2,0 m high;
- open outwards;
- have a means (e.g. panic bolts) to allow opening from the inside without the use of a key or tool;
- have a sufficient clearance for opening fully.

Exception: Where the dimensions of gangways and/or doors have to be locally reduced, for example, at bulkheads necessary for stiffening in box girders, the clear height may be reduced to not less than 1,4 m and/or the clear width to not less than 0,6 m at these points.

Where the measures provided for protection against unintended contact with live parts along the gangway are not sufficient for the areas immediately adjacent to these restrictions, additional measures for protection can be required (see 6.2). 29

11.5.3 Gangways in front of switchgear and controlgear

The clear width in front of switchgear and controlgear enclosures shall be at least 0,6 m, and for passing open enclosure doors shall be at least 0,4 m measured with the maximum door opening angle.

Enclosures which readily allow a person to fully enter, for example, for resetting, adjusting or maintenance, shall have a clear width of at least 0,7 m and a clear height of at least 2,0 m.

In cases where

- equipment is likely to be live during access, and
- conducting parts are exposed,

the clear width shall be at least ~~1,0~~ 0,9 m. In cases where such parts are present on both sides of the access way, the clear width shall be at least ~~1,5~~ 1,3 m.

~~11.5.4~~ Gangway and door restrictions

~~Where the dimensions of gangways and/or doors have to be locally reduced, for example, at bulkheads necessary for stiffening in box girders, the clear height may be reduced to not less than 1,4 m and/or the clear width to not less than 0,6 m at these points.~~

~~NOTE — Where the measures provided for protection against unintended contact with live parts along the gangway are not sufficient for the areas immediately adjacent to these restrictions, additional measures for protection can be required (see 6.2).~~ 30

12 Conductors and cables

12.1 General requirements

Conductors and cables shall be selected so as to be suitable for the operating conditions (e.g. voltage, current, protection against electric shock, grouping of cables) and external influences (e.g. ambient temperature, presence of water or corrosive substances, mechanical stresses (including stresses during installation), fire hazards) that can exist.

~~NOTE — Further information is given in CENELEC HD 516 S2.~~

These requirements do not apply to the integral wiring of assemblies, subassemblies, and devices that are manufactured and tested in accordance with their relevant IEC standard (e.g. ~~IEC 60439-1~~ IEC 61800 series).

When cables are installed on hoisting machines used in the open air (e.g. outside buildings or other protective structures), they shall be suitable for outdoor use (e.g. UV-resistant, adequate temperature range), or be ~~appropriately~~ otherwise protected (e.g. cable duct or other housing).

12.2 Conductors

~~In general,~~ Conductors ~~shall~~ should be of copper. Where aluminium conductors are used, the cross-sectional area shall be at least 16 mm².

To ensure adequate mechanical strength, the cross-sectional area of conductors ~~should~~ shall not be less than as shown in Table 5. However, conductors with smaller cross-sectional areas or other constructions than shown in Table 5 may be used in equipment provided adequate mechanical strength is achieved by other means and proper functioning is not impaired.

Table 5 – Minimum cross-sectional areas of copper conductors

		Type of conductor, cable				
Location	Application	Single core		Multi-core		
		Flexible (class 5 or class 6)	Solid (class 1) or stranded (class 2)	Two core, shielded	Two core, not shielded	Three or more cores, shielded or not
Wiring outside (protecting) enclosures	Power circuits, fixed	1,0	1,5	0,75	0,75	0,75
	Power circuits, subjected to frequent movements	1,0	-	0,75	0,75	0,75
	Control circuits	1,0	1,0	0,2	0,5	0,2
	Data communication	-	-	-	-	0,08
Wiring inside enclosures ^a	Power circuits (connections not moved)	0,75	0,75	0,75	0,75	0,75
	Control circuits	0,2	0,2	0,2	0,2	0,2
	Data communication	-	-	-	-	0,08
NOTE 1 All cross-sections in mm ² .						
NOTE 2 Annex F contains a comparison of typical conductor cross-sectional areas in American Wire Gauge (AWG), square millimetres, square inches, and circular mils.						
^a Except special requirements of individual standards; see also 12.1.						

NOTE Classification of conductors is given in Table 6.

Table 6 – Classification of conductors

Class	Description	Use/application
1	Solid copper or aluminium conductors	Fixed installations
2	Stranded copper or aluminium conductors	
5	Flexible stranded copper conductors	Machine installations with presence of vibration; connection to moving parts
6	Flexible stranded copper conductors that are more flexible than class 5	For frequent movements
NOTE Derived from IEC 60228.		

Class 1 and class 2 conductors are primarily intended for use between rigid, non-moving parts, and they may also be used where minimal flexing occurs provided that the cross-sectional area is less than 0,5 mm².

All conductors that are subject to frequent movement (e.g. one movement per hour of machine operation) shall have flexible stranding of class 5 or class 6.

12.3 Insulation

~~The types of insulation include, but are not limited to,~~ **31**

- polyvinyl chloride (PVC);
- rubber, natural and synthetic;
- silicone rubber (SiR);
- mineral;

~~—cross-linked polyethylene (XLPE);~~

~~—ethylene propylene compound (EPR).~~

Where the insulation of conductors and cables ~~(for example, PVC)~~ can constitute hazards due ~~for example~~ to the propagation of a fire or the emission of toxic or corrosive fumes, guidance from the cable supplier should be sought. It is important to give special attention to the integrity of a circuit having a safety-related control function.

The insulation of cables and conductors used shall be suitable for a test voltage:

- not less than 2 000 V AC for a duration of 5 min for operating at voltages higher than 50 V AC or 120 V DC; or
- not less than 500 V AC for a duration of 5 min for PELV circuits (see IEC 60364-4-41:2005, class III equipment).

The mechanical strength and thickness of the insulation shall be such that the insulation cannot be damaged in operation or during laying, especially for cables pulled into ducts.

NOTE ~~The effects of voltage and current waveform should be taken into account when selecting cables, for example adjustable speed drives can cause additional voltage stresses to the motor cable (see IEC 61800 series).~~

12.4 Current-carrying capacity in normal service

The current-carrying capacity depends on several factors, for example, insulation material, number of conductors in a cable, design (sheath), methods of installation, grouping and ambient temperature.

NOTE 1 Detailed information and further guidance can be found in IEC 60364-5-52, in some national standards or given by the manufacturer.

One typical example of the current-carrying capacities for PVC insulated wiring between enclosures and individual items of equipment under steady-state conditions is given in Table 7.

NOTE 2 For specific applications where the correct ~~conductor~~ cable dimensioning can depend on the relationship between the period of the duty cycle and the thermal time constant of the ~~conductor~~ cable (for example, starting against high-inertia load, intermittent duty), the ~~conductor~~ cable manufacturer ~~should be consulted~~ can provide information. ~~Conductor selection for intermittent duty should be made in accordance with the conductor manufacturers instructions.~~ If such information is not available, the criteria presented in Annex D can be used.

Table 7 – Examples of current-carrying capacity (I_z) of PVC-insulated copper conductors or cables under steady-state conditions in an ambient air temperature of +40 °C for different methods of installation 32

	Installation method (see C.2.2)			
	B1	B2	C	E
Cross-sectional area mm ²	Current-carrying capacity I_z for three-phase circuits			
	A			
0,75	8,6	8,5	9,8	10,4
1,0	10,3	10,1	11,7	12,4
1,5	13,5	13,1	15,2	16,1
2,5	18,3	17,4	21	22
4	24	23	28	30
6	31	30	36	37
10	44	40	50	52
16	59	54	66	70
25	77	70	84	88
35	96	86	104	110
50	117	103	125	133
70	149	130	160	171
95	180	156	194	207
120	208	179	225	240
	Control circuit pairs			
0,20	Not applicable 4,5	4,3	4,4	4,4
0,5	Not applicable 7,9	7,5	7,5	7,8
0,75	Not applicable 9,5	9,0	9,5	10

NOTE 1 The values of the current-carrying capacity of Table 7 are based on:

- one symmetrical three-phase circuit for cross-sectional areas 0,75 mm² and greater;
- one control circuit pair for cross-sectional areas between 0,2 mm² and 0,75 mm².

Where more loaded cables/pairs are installed, derating factors for the values of Table 7 ~~should~~ can be ~~derated~~ found in ~~accordance with~~ Table C.2 or Table C.3.

NOTE 2 For ambient temperatures other than 40 °C, ~~correct the current-carrying capacities by using values given~~ correction factors for current-carrying capacities are provided in Table C.1.

NOTE 3 These values are not applicable to flexible cables wound on drums (see 12.6.3).

NOTE 4 Current-carrying capacities of other cables are provided in IEC 60364-5-52.

12.5 Conductor and cable voltage drop

The voltage drop from the crane-supply-switch to the motors or, in the case of a semiconductor converter driven motor, to the line side of the converter, shall not exceed 5 % of the nominal voltage under normal operating conditions. In order to conform to this requirement, it may be necessary to use conductors having a larger cross-sectional area than that derived from Table 7.

NOTE If more information is not available, the voltage drop ~~may~~ can be calculated by using the starting current of the largest drive combined with the nominal current of the next largest drive. When there is more than one hoisting machine on a common power supply, a proven simultaneity factor ~~may~~ can be used.

In control circuits, the voltage drop shall not reduce the voltage at any device below the manufacturer's specification for that device, taking into account inrush currents.

The voltage drop in components, for example overcurrent protective devices and switching devices, should be considered.

12.6 Flexible cables

12.6.1 General

Flexible cables shall have class 5 or class 6 conductors.

NOTE 1 Class 6 conductors have smaller diameter strands and are more flexible than class 5 conductors (see Table 6).

Cables that are subjected to severe duties shall be of adequate construction to protect against

- abrasion due to mechanical handling and dragging across rough surfaces;
- kinking due to operation without guides;
- stress resulting from guide rollers and forced guiding, being wound and re-wound on cable drums.

NOTE 2 Cables for such conditions are specified in national standards.

NOTE 3 The operational life of the cable will be reduced where unfavourable operating conditions such as high tensile stress, small radii, bending into another plane and/or where frequent duty cycles coincide.

12.6.2 Mechanical rating

The cable-handling system of the hoisting machine shall be so designed to keep the tensile stress of the conductors as low as is practicable during hoisting machine operations. Where copper conductors are used, the tensile stress applied to the conductors shall not exceed 15 N/mm² of the copper cross-sectional area. Where the demands of the application exceed the tensile stress limit of 15 N/mm², cables with special construction features should be used and the allowed ~~maximal~~ maximum tensile stress should be agreed with the cable manufacturer.

The maximum stress applied to the conductors of flexible cables with material other than copper shall be within the cable manufacturer's specification.

NOTE The following conditions affect the tensile stress on the conductors:

- acceleration forces;
- speed of motion;
- dead (hanging) weight of the cables;
- method of guiding;
- design of cable drum system.

12.6.3 Current-carrying capacity of cables wound on drums

Cables to be wound on drums shall be selected with conductors having a cross-sectional area such that, when fully wound on the drum and carrying the normal service load, the maximum allowable conductor temperature is not exceeded.

For cables of circular cross-sectional area installed on drums, the maximum current-carrying capacity in free air ~~should~~ shall be derated in accordance with Table 8.

NOTE The current-carrying capacity of cables in free air can be found in manufacturers' specifications or in relevant national standards.

Table 8 – Derating factors for cables wound on drums

Drum type	Number of layers of cable				
	Any number	1	2	3	4
Cylindrical ventilated	–	0,85	0,65	0,45	0,35
Radial ventilated	0,85	–	–	–	–
Radial non-ventilated	0,75	–	–	–	–

It is recommended that the use of derating factors be discussed with the cable and the cable drum manufacturers. This may result in other factors being used.

NOTE 1 A radial type drum is one where spiral layers of cable are accommodated between closely spaced flanges; if fitted with solid flanges, the drum is described as non-ventilated and, if the flanges have suitable apertures, as ventilated.

NOTE 2 A ventilated cylinder drum is one where the layers of cable are accommodated between widely spaced flanges and the drum and end flanges have ventilating apertures.

12.7 Conductor wires, conductor bars and slip-ring assemblies

12.7.1 ~~Protection against direct contact~~ Basic protection

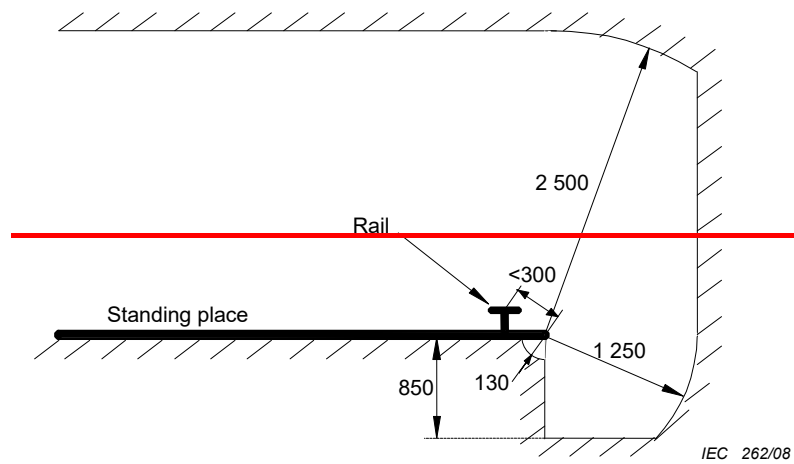
Conductor wires, conductor bars and slip-ring assemblies shall be installed or enclosed in such a way that, during normal access to the hoisting machines (for example, via gangways along a crane track or along a crane girder), ~~basic protection against direct contact~~ basic protection is achieved by the application of one of the following protective measures:

- protection by partial insulation of live parts or, where this is ~~the preferred measure~~ not practicable,
- protection by enclosures or barriers of at least IP2X or IPXXB (see IEC 60364-4-41:2005, Clause A.2).

Horizontal top surfaces of barriers or enclosures which are readily accessible shall provide a degree of protection of at least IP4X or IPXXD.

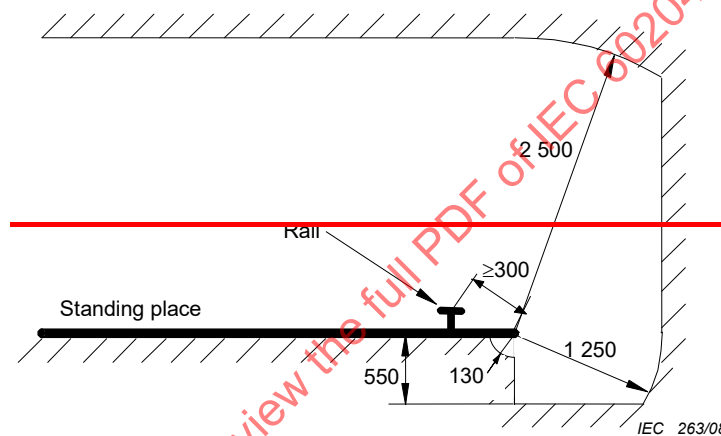
Where the required degree of protection is not achieved, one of the following additional protective measures shall be applied:

- a) protection by placing live parts out of reach (see IEC 60364-4-41:2005, Clause B.3) in combination with emergency switching-off in accordance with 9.2.5.4.3 or, where this is not practicable,
- b) protection by compliance with the limits (derived from ~~ISO 13852~~ ISO 13857) given in Figure 18, Figure 19 and Figure 20. This measure is intended to be used in areas where only skilled or instructed persons have access and where special conditions exist (e.g. hot area of steel mills or in chemical plants).



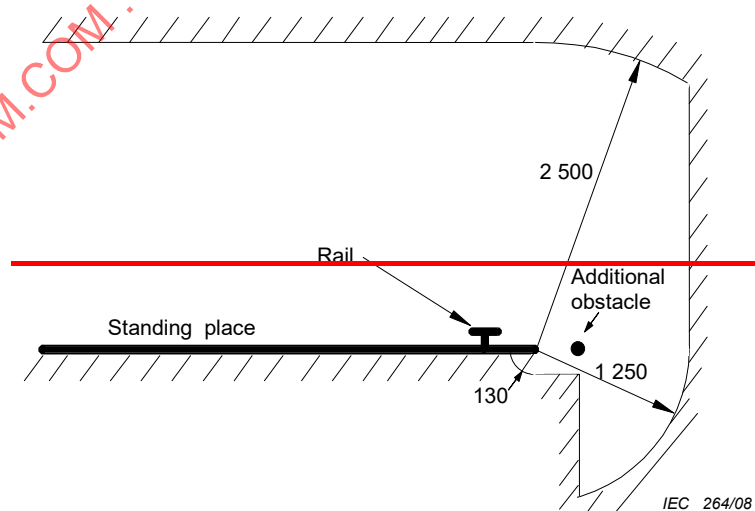
Dimensions in millimetres

Figure 7a — Limit of arm's reach in cases where the distance from the middle of the hoisting device rail to the edge of the girder is less than 300 mm



Dimensions in millimetres

Figure 7b — Limit of arm's reach in cases where the distance from the middle of the hoisting device rail to the edge of the girder is at least 300 mm



Dimensions in millimetres

Figure 7c — Limit of arm's reach in cases of using additional obstacles

Figure 7 — Limits of arm's reach

Dimensions in millimetres

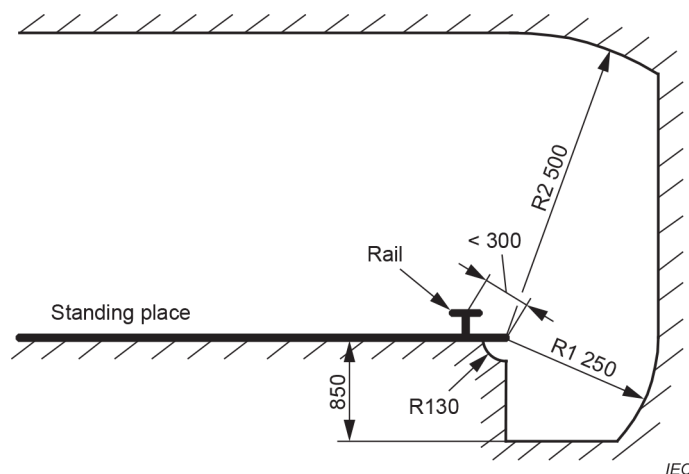


Figure 18 – Limit of arm's reach in cases where the distance from the middle of the hoisting device-rail to the edge of the girder is less than 300 mm

Dimensions in millimetres

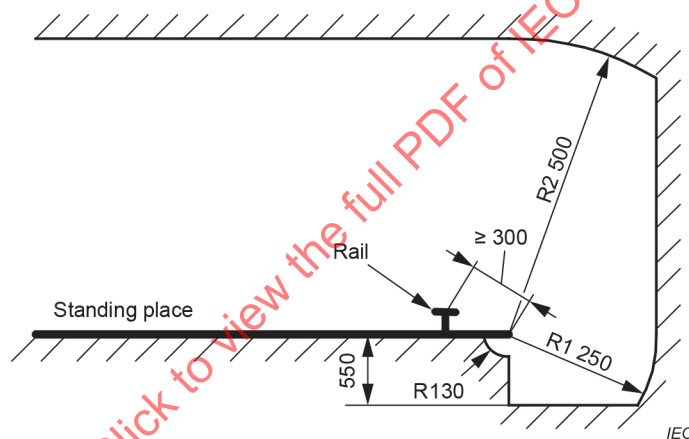


Figure 19 – Limit of arm's reach in cases where the distance from the middle of the hoisting device-rail to the edge of the girder is at least 300 mm

Dimensions in millimetres

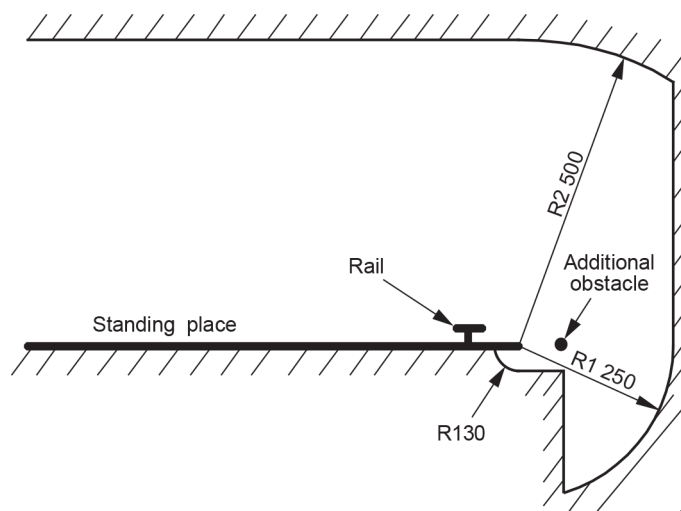


Figure 20 – Limit of arm's reach in cases of using additional obstacles

NOTE Examples of obstacles located above unprotected conductor wires or conductor bars are guard-rails, mesh-screens.

Conductor wires and conductor bars shall be so placed and/or protected as to

- prevent contact, especially for unprotected conductor wires and conductor bars, with conductive items such as the cords of pull-cord switches, strain-relief devices and drive chains;
- prevent damage from a swinging load.

Where the required degree of protection provided for conductor wires or conductor bars is not effective (e.g. adjacent to current collectors), additional means shall be provided (e.g. additional obstacles).

If circuits of different crane-disconnectors are run through conductor wires, conductor bars or slip-ring assemblies, each subcircuit system shall be protected against direct contact with a degree of protection of at least IP2X or IPXXB (see IEC 60529).

12.7.2 Protective conductor circuit

Where conductor wires, conductor bars and slip-ring assemblies are installed as part of the protective bonding circuit, they shall not carry current in normal operation. Therefore, the protective conductor (PE) and the neutral conductor (N) shall each use a separate conductor wire, conductor bar or slip-ring. The continuity of the protective conductor circuit using sliding contacts shall be ensured by taking appropriate measures (e.g. duplication of the current collector, continuity monitoring).

12.7.3 Protective conductor current collectors

Protective conductor current collectors shall have a shape or construction so that they are not interchangeable with the other current collectors. Such current collectors shall be of the sliding contact type.

It is recommended that protective current collectors be identified by the colour combination GREEN-AND-YELLOW or marked by symbol IEC 60417-5019 (2006-08) (see Figure 21) or symbol PE, at least at connection points.

12.7.4 Removable current collectors with a disconnecter function

Removable current collectors having a disconnecter function shall be so designed that the protective conductor circuit is interrupted only after the live conductors have been disconnected, and the continuity of the protective conductor circuit is re-established before any live conductor is reconnected (see also 8.2.4).

12.7.5 Clearances in air

Clearances between the respective conductors, and between adjacent systems, of conductor wires, conductor bars, slip-ring assemblies and their current collectors shall be suitable for at least a rated impulse voltage of an overvoltage category III in accordance with IEC 60664-1.

12.7.6 Creepage distances

Creepage distances between the respective conductors, and between adjacent systems of conductor wires, conductor bars and slip-ring assemblies, and their current collectors shall be suitable for operation in the intended environment ~~(see IEC 60664-1, 2.5)~~, for example open air, inside buildings, protected by enclosures.

NOTE Equipment designed to operate in pollution degree 3 conditions is suitable for most applications.

In abnormally dusty, moist or corrosive environments, the following creepage distance requirements apply.

- Unprotected conductor wires, conductor bars, and slip-ring assemblies shall be equipped with insulators with a minimum creepage distance of 60 mm.
- Enclosed conductor wires, insulated multi-pole conductor bars and insulated individual conductor bars shall have a minimum creepage distance of 30 mm.

The manufacturer's recommendations shall be followed regarding special measures to prevent a gradual reduction in the insulation values due to unfavourable ambient conditions (e.g. deposits of conductive dust, chemical attack).

12.7.7 Conductor system sectioning

Where conductor wires or conductor bars are arranged so that they can be divided into isolated sections, suitable design measures shall be employed to prevent the energization of adjacent sections by the current collectors themselves.

12.7.8 Construction and installation of conductor wire, conductor bar systems and slip-ring assemblies

Conductor wires, conductor bars and slip ring assemblies used for power circuits shall be grouped separately from those used for control circuits.

Conductor wires, conductor bars and slip-ring assemblies shall be capable of withstanding, without damage, the mechanical forces and thermal effects of short-circuit currents.

Removable covers for conductor wire and conductor bar systems laid underground or underfloor shall be so designed that they cannot be opened by one person without the aid of a tool.

Where conductor bars are installed in a common metal enclosure, the individual sections of the enclosure shall be bonded together and earthed at several points depending upon their length. Metal covers of conductor bars laid underground or underfloor shall also be bonded together and ~~earthed~~ connected to the protective bonding circuit.

NOTE ~~For the protective bonding together of covers or cover plates of metal enclosures or underfloor ducts, the metal hinges are considered sufficient to ensure continuity.~~

~~Underground and underfloor conductor bar ducts shall have drainage facilities.~~

The protective bonding circuit shall include the covers or cover plates of metal enclosures or underfloor ducts. Where metal hinges form a part of the protective bonding circuit, their continuity shall be verified (see Clause 18).

Conductor bar ducts that can be subject to accumulation of liquid such as oil or water shall have drainage facilities.

13 Wiring practices

13.1 Connections and routing

13.1.1 General requirements

All connections, especially those of the protective bonding circuit shall be secured against accidental loosening.

The means of connection shall be suitable for the cross-sectional areas and nature of the conductors being terminated.

The connection of two or more conductors to one terminal is permitted only in those cases where the terminal is designed for that purpose. However, only one protective conductor shall be connected to one terminal connecting point.

Soldered connections shall only be permitted where terminals are provided that are suitable for soldering.

Terminals on terminal blocks shall be plainly marked or labelled to correspond with ~~markings on~~ the identification used in the diagrams.

NOTE IEC 61666 provides rules that can be used for the designation of terminals within the electrical equipment.

Where an incorrect electrical connection (e.g. arising from replacement of devices) ~~can be~~ is identified as a source of risk that needs to be reduced and it is not practicable to reduce the possibility of incorrect connection by design measures, the conductors and/or terminations shall be identified ~~in accordance with 13.2.1.~~

The installation of flexible conduits and cables shall be such that liquids shall drain away from the fittings.

Means of retaining conductor strands shall be provided when terminating conductors at devices or terminals that are not equipped with this facility. Solder shall not be used for that purpose.

Shielded conductors shall be so terminated as to prevent fraying of strands and to permit easy disconnection.

Identification tags shall be legible, permanent, and appropriate for the physical environment.

Terminal blocks shall be mounted and wired so that the ~~internal and external~~ wiring does not cross over the terminals.

13.1.2 Conductor and cable runs

Conductors and cables shall be run from terminal to terminal without splices or joints. Connections using plug/socket combinations with suitable protection against accidental disconnection are not considered to be splices or joints for the purpose of 13.1.2.

Exception: Where it is impracticable to provide terminals in a junction box (e.g. on hoisting machines having long flexible cables; cable connections exceeding a length which is not practical to be supplied by the cable manufacturer on one cable drum; ~~repair of cable due to mechanical stresses during installation and operation~~), splices or joints may be used.

Where it is necessary to connect and disconnect cables and cable assemblies, a sufficient extra length shall be provided for that purpose.

The terminations of cables shall be adequately supported to prevent mechanical stresses at the terminations of the conductors.

Wherever practicable, the protective conductor shall be placed close to the associated live conductors in order to decrease the impedance of the loop.

13.1.3 Conductors of different circuits

Conductors of different circuits may be laid side by side, may occupy the same duct (e.g. conduit, cable trunking system), or may be in the same multi-conductor cable ~~or in the same plug/socket combination~~ provided that the arrangement does not impair the proper functioning of the respective circuits and:

- where those circuits operate at different voltages, the conductors shall be separated by suitable barriers or
- ~~the conductors~~ shall be insulated for the highest voltage to which any conductor within the same duct can be subjected, for example line-to-line voltage for unearthed systems and phase-to-earth voltage for earthed systems.

13.1.4 AC circuits – Electromagnetic effects (prevention of eddy currents) 33

Conductors of AC circuits installed in ferromagnetic enclosures shall be arranged so that all conductors of each circuit, including the protective conductor of each circuit, are contained in the same enclosure. Where such conductors enter a ferrous enclosure, they shall be arranged such that the conductors are not individually surrounded by ferromagnetic material.

Single-core cables armoured with steel wire or steel tape should not be used for AC circuits.

The steel wire or steel tape armour of a single-core cable is regarded as a ferromagnetic enclosure. For single-core wire armoured cables, the use of aluminium armour is recommended.

NOTE See also IEC 60364-5-52.

13.1.5 Connection between pick-up and pick-up converter of an inductive power supply system

The cable between the pick-up and the pick-up converter ~~of the inductive power supply~~ shall be

- as specified by the power supply system manufacturer;
- as short as practicable;
- adequately protected against mechanical damage.

NOTE The output of the pick-up can be a current source; therefore, damage to the cable can result in a high voltage hazard.

13.2 Identification of conductors

13.2.1 General requirements

Each conductor shall be identifiable at each termination in accordance with the technical documentation (see Clause 17).

It is recommended (e.g. to facilitate maintenance) that conductors be identified by number, alphanumeric, colour (either solid or with one or more stripes), or a combination of colour and numbers or alphanumeric. When numbers are used, they shall be arabic; letters shall be roman (either upper- or lower-case).

NOTE 1 Annex B can be used for agreement between supplier and user regarding a preferred method of identification.

NOTE 2 IEC 62491 provides rules and guidelines for the labelling of cables and cores/conductors used in industrial installations, equipment and products.

13.2.2 Identification of the protective conductor / protective bonding conductor

The protective conductor / protective bonding conductor shall be readily distinguishable from other conductors by shape, location, marking, or colour. When identification is by colour alone, the bicolour combination GREEN-AND-YELLOW shall be used throughout the length of the conductor. This colour identification is strictly reserved for the protective conductor / protective bonding conductors.

For insulated conductors, the bicolour combination GREEN-AND-YELLOW shall be such that on any 15 mm length one of the colours covers at least 30 % and not more than 70 % of the surface of the conductor, the other colour covering the remainder of the surface.

Where the protective conductor can be easily identified by its shape, position, or construction (e.g. a braided conductor, uninsulated stranded conductor), or where the insulated conductor is not readily accessible or is part of a multicore cable, colour coding throughout its length is not necessary but the ends or accessible locations shall be clearly identified by the graphical symbol IEC 60417-5019 (2002-10) (see Figure 21) or with the letters PE or by the bicolour combination GREEN-AND-YELLOW.

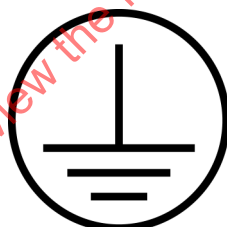


Figure 21– Symbol IEC 60417-5019

Exception: Protective bonding conductors may be marked with the letters PB and/or the symbol IEC 60417-5021 (2002-10) (see Figure 22).



Figure 22 – Symbol IEC 60417-5021

13.2.3 Identification of the neutral conductor

Where a circuit includes a neutral conductor that is identified by colour alone, the colour used for this conductor shall be BLUE. In order to avoid confusion with other colours, it is recommended that an unsaturated blue be used, called here “light blue” (see 6.2.2 of IEC 60446).

IEC 60445:2021). Where the selected colour is the sole identification of the neutral conductor, that colour shall not be used for identifying any other conductor where confusion is possible.

Where identification by colour is used, bare conductors used as neutral conductors shall be either coloured by a stripe, 15 mm to 100 mm wide in each compartment or unit and at each accessible location, or coloured throughout their length.

13.2.4 Identification by colour

Where colour-coding is used for identification of conductors (other than the protective conductor (see 13.2.2) and the neutral conductor (see 13.2.3)), the following colours may be used:

BLACK, BROWN, RED, ORANGE, YELLOW, GREEN, BLUE (including LIGHT BLUE), VIOLET, GREY, WHITE, PINK, TURQUOISE.

NOTE This list of colours is derived from IEC 60757.

It is recommended that, where colour is used for identification, the colour be used throughout the length of the conductor either by the colour of the insulation or by colour markers at regular intervals and at the ends or accessible location.

For safety reasons, the colour GREEN or the colour YELLOW should not be used where there is a possibility of confusion with the bicolour combination GREEN-AND-YELLOW (see 13.2.2).

Colour identification using combinations of those colours listed above may be used provided there can be no confusion and that GREEN or YELLOW is not used except in the bicolour combination GREEN-AND-YELLOW.

Where colour-coding is used for identification of conductors, it is recommended that they be colour-coded as follows:

- BLACK: AC and DC power circuits;
- RED: AC control circuits;
- BLUE: DC control circuits;
- ORANGE: special circuits in accordance with 5.3.8.

~~Exceptions to the above are permitted where~~

- ~~— insulation is used that is not available in the colours recommended; or~~
- ~~— multi-conductor cable is used, but not the bicolour combination GREEN-AND-YELLOW.~~

Exceptions to the above are permitted where insulation is not available in the colours recommended (for example in multiconductor cables).

13.3 Wiring inside enclosures

Conductors inside enclosures shall be supported where necessary to keep them in place. Non-metallic ducts shall be permitted only when they are made with a flame-retardant insulating material (see the IEC 60332 series).

It is recommended that electrical equipment mounted inside enclosures be designed and constructed in such a way as to permit modification of the wiring from the front of the enclosure (see also 11.2.1). Where that is not practicable and control devices are connected from the rear of the enclosure, access doors or swing-out panels shall be provided.

Connections to devices mounted on doors or to other movable parts shall be made using flexible conductors in accordance with 12.2 and 12.6 to allow for the frequent movement of the part. The conductors shall be anchored to the fixed part and to the movable part independently of the electrical connection (see also 8.2.3 and 11.2.1).

Conductors and cables that do not run in ducts shall be adequately supported.

Terminal blocks or plug/socket combinations shall be used for control wiring that extends beyond the enclosure. For plug/socket combinations, see also 13.4.5 and 13.4.6.

Power cables and cables of measuring circuits may be directly connected to the terminals of the devices for which the connections were intended.

13.4 Wiring outside enclosures

13.4.1 General requirements

The means of introduction of cables or ducts with their individual glands, bushings, etc., into an enclosure shall ensure that the degree of protection is not reduced (see 11.3).

Conductors of a circuit shall not be distributed over different multi-core cables, conduits, cable ducting systems or cable trunking systems. This is not required where a number of multi-core cables, forming one circuit, are installed in parallel. Where multi-core cables are installed in parallel, each cable shall contain one conductor of each phase and the neutral if any.

13.4.2 External ducts

Conductors and their connections external to the electrical equipment enclosure(s) shall be enclosed in suitable ducts (i.e. conduit or cable trunking systems) as described in 13.5 except for suitably protected cables that may be installed without ducts and with or without the use of open cable trays or cable support means. Where devices such as position switches or proximity switches are supplied with a dedicated cable, their cable need not be enclosed in a duct when the cable is suitable for the purpose, sufficiently short, and so located or protected, that the risk of damage is minimized.

Fittings used with ducts or ~~multi-conductor cable~~ cables shall be suitable for the physical environment.

Flexible conduit or flexible multi-conductor cable shall be used where it is necessary to employ flexible connections to pendant push-button stations. The weight of the pendant stations shall be supported by means other than the flexible conduit or the flexible multi-conductor cable, except where the conduit or cable is specifically designed for that purpose.

Flexible conduit or flexible multi-conductor cable shall be used for connections involving small or infrequent movements. They shall also be permitted to complete the connection to normally stationary motors, to position switches, and to other externally mounted devices.

13.4.3 Connection to the hoisting machine and to moving elements on the hoisting machine

~~Connections to moving elements, and to the hoisting machine where it is intended to be moved, shall be made using conductors in accordance with 12.2 and 12.6, taking into account the intended frequency of movement.~~ The design of connections to moving parts shall take into account the foreseeable frequency of movement and shall be made using conductors in accordance with 12.2 and 12.6. Flexible cable and flexible conduit shall be so installed as to avoid excessive flexing and straining, particularly at the fittings.

Cables subject to movement shall be supported in such a way that there is no mechanical strain on the connection points nor any sharp flexing. When this is achieved by the provision of a loop, it shall have sufficient length to provide for a bending radius of the cable ~~of~~ as specified by the cable manufacturer or, if no such specification is given, at least 10 times the diameter of the cable.

Flexible cables of hoisting machines shall be so installed or protected as to minimize the possibility of external damage due to factors that include the following cable use or potential abuse:

- being run over by the hoisting machine itself;
- being run over by other machines or vehicles;
- coming into contact with the hoisting machine structure during movements;
- running in and out of cable baskets, or on or off cable drums;
- acceleration forces and wind forces on festoon systems or suspended cables;
- misalignment of energy chain systems;
- excessive rubbing by cable collector;
- exposure to excessive radiated heat.

The cable sheath shall be resistant to the normal wear that can be expected from movement and to the effects of environmental contaminants (e.g. oil, water, coolants, dust).

Where cables subject to movement are close to moving parts, precautions shall be taken to maintain a space of at least 25 mm between the moving parts and the cables. Where that distance is not practicable, fixed barriers shall be provided between the cables and the moving parts.

The cable handling system shall be so designed that lateral cable angles do not exceed 5°, avoiding torsion in the cable when

- being wound on and off cable drums, and
- approaching and leaving cable guidance devices.

Measures shall be taken to ensure that at least two turns of flexible cables always remain on a drum.

Devices serving to guide and carry a flexible cable shall be so designed that the inner bending radius at all points where the cable is bent is not less than the values given in Table 9, unless otherwise agreed with the cable manufacturer, taking into account the permissible tension and the expected fatigue life.

Table 9 – Minimum permitted bending radii for the forced guiding of flexible cables

Application	Cable diameter or thickness of flat cable (d)		
	mm		
	$d \leq 8$	$8 < d \leq 20$	$d > 20$
Cable drums	$6 d$	$6 d$	$8 d$
Guide rollers	$6 d$	$8 d$	$8 d$
Festoon systems	$6 d$	$6 d$	$8 d$
All others	$6 d$	$6 d$	$8 d$

The straight section between two bends shall be at least 20 times the diameter of the cable. Where flexible conduit is adjacent to moving parts, the construction and supporting means shall prevent damage to the flexible conduit under all conditions of operation.

Flexible conduit shall not be used for connections subject to rapid or frequent movements except when specifically designed for that purpose.

13.4.4 Interconnection of devices on the hoisting machine

Where several hoisting machine-mounted ~~switching~~ devices (e.g. position sensors, push-buttons) are connected in series or in parallel, it is recommended that the connections between those devices be made through terminals forming intermediate test points. Such terminals shall be conveniently placed, adequately protected, and shown on the relevant diagrams.

13.4.5 Plug/socket combinations

~~Where plug/socket combinations are provided, they shall fulfil one or more of the following requirements as applicable.~~

Exception: ~~The following requirements do not apply to~~ Components or devices inside an enclosure, terminated by fixed plug/socket combinations (no flexible cable), or components connected to a bus system by a plug/socket combination, ~~are not considered to be plug/socket combinations for the purpose of 13.4.5.~~

Where plug/socket combinations are provided, they shall fulfil one or more of the following requirements as applicable.

- a) When installed correctly in accordance with f), plug/socket combinations shall be of such a type as to prevent unintentional contact with live parts at any time, including during insertion or removal of the connectors. The degree of protection shall be at least IPXXB. PELV and SELV circuits are excepted from this requirement.
- b) Plug/socket combinations shall have a first-make last-break protective bonding contact (earthing contact) (see also 6.3, 8.2.4) if used in TN- or TT-systems.
- c) Plug/socket combinations intended to be connected or disconnected during load conditions shall have sufficient load-breaking capacity. Where such a plug/socket combination is rated at 32 A, or greater, it shall be interlocked with a switching device so that the connection and disconnection is possible only when the switching device is in the OFF position.
- d) Plug/socket combinations that are rated at more than 16 A shall have a retaining means to prevent unintended or accidental disconnection.
- e) Where an unintended or accidental disconnection of plug/socket combinations can cause a hazardous situation, they shall have a retaining means.

The installation of plug/socket combinations shall fulfil the following requirements as applicable.

- f) The component which remains live after disconnection shall have a degree of protection of at least IP2X or IPXXB, taking into account the required clearance and creepage distances. PELV and SELV circuits are excepted from this requirement.
- g) Metallic housings of plug/socket combinations shall be connected to the protective bonding circuit. PELV and SELV circuits are excepted from this requirement.
- h) Plug/socket combinations intended to carry power loads but not to be disconnected during load conditions shall have a retaining means to prevent unintended or accidental disconnection and it shall be clearly marked that they are not intended to be disconnected under load.
- i) Where more than one plug/socket combination is provided in the same electrical equipment, the associated combinations shall be clearly identifiable. It is recommended that mechanical coding be used to prevent incorrect insertion.
- j) Plug/socket combinations used in control circuits shall fulfil the applicable requirements of IEC 61984. ~~Exception: see k).~~

~~k) Plug/socket combinations intended for household and similar general purposes shall not be used for control circuits.~~ **34**

Exception: In plug/socket combinations in accordance with IEC 60309-1, only those contacts shall be used for control circuits which are intended for those purposes. This exception does not apply to control circuits using high frequency signals superimposed on the power circuits.

~~Exception: The requirements of k) do not apply to control functions using high frequency signals on the power supply.~~

13.4.6 Dismantling for shipment

Where it is necessary that wiring is disconnected for shipment, terminals or plug/socket combinations shall be provided at the sectional points. Such terminals shall be suitably enclosed and plug/socket combinations shall be protected from the physical environment during transportation and storage.

13.4.7 Additional conductors

Consideration should be given to providing additional conductors for maintenance or repair. When spare conductors are provided, they shall be connected to spare terminals or isolated in such a manner as to prevent contact with live parts.

13.5 Ducts, connection boxes and other boxes

13.5.1 General requirements

Ducts shall provide a degree of protection (see IEC 60529) suitable for the application.

All sharp edges, flash, burrs, rough surfaces, or threads with which the insulation of the conductors can come in contact shall be removed from ducts and fittings. Where necessary, additional protection consisting of a flame-retardant, oil-resistant insulating material shall be provided to protect conductor insulation.

Drain holes of 6 mm diameter are permitted in cable trunking systems, connection boxes, and other boxes used for wiring purposes that can be subject to accumulations of oil or moisture.

In order to prevent confusion of conduits with oil, air, or water piping, it is recommended that the conduits be either physically separated or suitably identified.

Ducts and cable trays shall be rigidly supported and positioned at a sufficient distance from moving parts and in such a manner so as to minimize the possibility of damage or wear. In areas where human passage is required, the ducts and cable trays shall be mounted to give at least the clearance specified in 11.5.

~~Ducts shall be provided only for mechanical protection (see 8.2.3 for requirements for connection to the protective bonding circuit).~~

Cable trays that are partially covered should not be considered to be ducts or cable trunking systems (see 13.5.6), and the cables used shall be of a type suitable for installation ~~with or without the use of open cable trays or cable support means~~ on open cable trays.

13.5.2 Percentage fill of ducts

Consideration of the percentage fill of ducts should be based on the straightness and length of the duct and the flexibility of the conductors. It is recommended that the dimensions and arrangement of the ducts be such as to facilitate the insertion of the conductors and cables.

13.5.3 Rigid metal conduits and fittings

Rigid metal conduit and fittings shall be of galvanized steel or of a corrosion-resistant material suitable for the conditions. ~~The use of dissimilar metals in contact that can cause galvanic action should be avoided.~~ Where galvanic action is possible between dissimilar metals, these metal combinations shall not be used.

Conduits shall be securely held in place and supported at each end.

Fittings shall be compatible with the conduit and appropriate for the application. Fittings ~~shall~~ **should** be threaded unless structural difficulties prevent assembly. Where threadless fittings are used, the conduit shall be securely fastened to the equipment.

Conduit bends shall be made in such a manner that the conduit shall not be damaged and the internal diameter of the conduit shall not be effectively reduced.

13.5.4 Flexible metal conduits and fittings

A flexible metal conduit shall consist of a flexible metal tubing or woven wire armour. It shall be suitable for the expected physical environment.

Fittings shall be compatible with the conduit and appropriate for the application.

13.5.5 Flexible non-metallic conduits and fittings

Flexible non-metallic conduit shall be resistant to kinking and shall have physical characteristics similar to those of the sheath of multi-conductor cables.

The conduit shall be suitable for use in the expected physical environment.

Fittings shall be compatible with the conduit and appropriate for the application.

13.5.6 Cable trunking systems

Cable trunking systems external to enclosures shall be rigidly supported and clear of all moving ~~or contaminating portions~~ **parts** of the hoisting machine **and of sources of contamination**.

Covers shall be shaped to overlap the sides, gaskets are permitted. Covers shall be attached to cable trunking systems by suitable means. On horizontal cable trunking systems, the cover shall not be on the bottom unless specifically designed for such installation.

NOTE Requirements for cable trunking and ducting systems for electrical installations are given in IEC 61084 (all parts).

Where the cable trunking system is furnished in sections, the joints between sections shall fit tightly but need not be gasketed.

The only openings permitted shall be those required for wiring or for drainage. Cable trunking systems shall not have opened but unused knockouts.

13.5.7 Hoisting machine compartments and cable trunking systems

Compartments or cable trunking systems may be used within a hoisting machine to enclose conductors provided that the compartments or cable trunking systems are isolated from coolant or oil reservoirs and are entirely enclosed. Conductors run in enclosed compartments and cable trunking systems shall be so secured and arranged that they are not subject to damage.

13.5.8 Connection boxes and other boxes

Connection boxes and other boxes used for wiring purposes shall be accessible for maintenance. Those boxes shall provide protection against the ingress of solid bodies and liquids, taking into account the external influences under which the hoisting machine is intended to operate (see 11.3). The construction shall be sufficient to protect against mechanical damage in normal use.

Those boxes shall not have unused openings and they shall provide adequate protection against materials such as dust, flyings, oil, and coolant.

13.5.9 Motor connection boxes

Motor connection boxes shall enclose only connections to the motor and motor-mounted devices (e.g. brakes, temperature sensors, plugging switches, tachometer generators).

14 Electric motors and associated equipment

14.1 General requirements

Electric motors should conform to the relevant parts of IEC 60034 series.

The protection requirements for motors and associated equipment are given in 7.2 for overcurrent protection, in 7.3 for protection against overheating, and in 7.6 for overspeed protection.

As many controllers do not switch off the supply to a motor when it is at rest, ~~care shall be taken to ensure~~ compliance with the requirements of 5.3, 5.4, 5.5, 7.5, 7.6 and 9.4 ~~shall be ensured~~. Motor control equipment shall be located and mounted in accordance with Clause 11.

14.2 Motor enclosures

~~It is recommended that motor enclosures are chosen from those included in IEC 60034-5.~~

~~The degree of protection shall be at least IP23 (see IEC 60529) for all motors. More stringent requirements may be necessary depending on the application and the physical environment (see 4.4). Motors incorporated as an integral part of the hoisting machine shall be so mounted that they are adequately protected from mechanical damage.~~

Enclosures for motors should be in accordance with IEC 60034-5. **35**

The degree of protection shall be dependent on the application and the physical environment (see 4.4).

All motors shall be adequately protected from mechanical damage.

14.3 Motor dimensions

As far as is practicable, the dimensions of motors shall conform to those given in ~~the IEC 60072 series~~ IEC 60072-1, IEC 60072-2 or IEC 60072-3, as applicable.

14.4 Motor mounting and compartments

Each motor and its associated couplings, belts, pulleys or chains shall be mounted so that they are adequately protected and easily accessible for inspection, maintenance, adjustment and alignment, lubrication, and replacement. The motor mounting arrangement shall be such that all motor ~~hold-down~~ mounting means can be removed and all terminal boxes are accessible.

Motors shall be so mounted that proper cooling is ensured and the temperature rise remains within the limits of the insulation class (see IEC 60034-1:2017).

Where practicable, motor compartments should be clean and dry, and when required, shall be ventilated directly to the exterior of the hoisting machine. The vents shall be such that ingress of ~~swarf~~, dust or water spray is at an acceptable level.

There shall be no opening between the motor compartment and any other compartment that does not meet the motor compartment requirements. Where a conduit or pipe is run into the

motor compartment from another compartment not meeting the motor compartment requirements, any clearance around the conduit or pipe shall be sealed.

14.5 Criteria for motor selection

The characteristics of motors and associated equipment shall be selected in accordance with the anticipated service and physical environmental conditions (see Annex B and 4.4). In this respect, the points that shall be considered include

- type of motor;
- type of duty cycle (see IEC 60034-1:2017);
- expected frequency of starting;
- fixed speed or variable speed operation (and the consequent variable influence of the ventilation);
- mechanical vibration;
- type of motor control ~~(particularly when the motor is supplied from a semiconductor converter);~~

~~NOTE For example, the effects of adjustable speed a.c. drives on motors are described in more detail in IEC 61800-2, IEC 60034-17 and IEC/TR 60034-25.~~

- temperature rise and other effects of the frequency spectrum of the voltage and/or current feeding the motor (particularly when it is supplied from a converter);
- method of starting and the possible influence of the inrush current on the operation of other users of the same power supply, taking also into account possible special considerations stipulated by the supply authority;
- variation of counter-torque load with time and speed;
- influence of loads with large inertia;
- influence of constant torque or constant power operation;
- possible need of inductive reactors between motor and converter.

14.6 Protective devices for mechanical brakes

Operation of the overload and overcurrent protective devices for mechanical brake actuators shall initiate the simultaneous de-energization (release) of the associated hoisting machine actuators.

NOTE Associated hoisting machine actuators are those associated with the same motion, for example, cable drums and long-travel drives.

14.7 Electrically operated mechanical brakes

Where electrically operated mechanical brakes which are applied by removal of power are used, removal of power to motion drives shall result in removal of power to the associated brakes.

Exception: Operational braking in travel and slewing drives may use other methods of brake control.

15 ~~Accessories~~ Socket-outlets and lighting

15.1 Socket-outlets for accessories

Where the hoisting machine or its associated equipment is provided with socket-outlets that are intended to be used for accessory equipment (e.g. hand-held power tools, test equipment), ~~13.4.5 and~~ the following apply.

- The socket-outlets should conform to IEC 60309-1. Where that is not practicable, they should be clearly marked with the voltage and current ratings.

- The socket outlet shall include a protective bonding connection except where protection is provided by PELV.

NOTE Where it is necessary for operational purposes for some equipment to be isolated from the protective bonding circuit, such socket-outlets ~~may~~ can be excluded from this requirement.

- All unearthed conductors connected to the socket-outlet shall be protected against overcurrent and, when required, against overload in accordance with 7.2 and 7.3 separately from the protection of other circuits.
- Where the power supply to the socket-outlet is not disconnected by the crane-disconnector, the requirements of 5.3.8 apply.
- In circuits for socket outlets with a current rating not exceeding 32 A and accessible from outside the enclosure or enclosed electrical operating area, fault protection ~~against indirect contact~~ by automatic disconnection (see 6.3.3, measure a) is not sufficient without additional protective measures (e.g. RCDs with a rated residual operating current not exceeding 30 mA).

~~NOTE 1 See also Annex B, item 11.~~

15.2 Local lighting ~~on~~ of the hoisting machine and ~~for~~ of the equipment

15.2.1 General

Connections to the protective bonding circuit shall be in accordance with 8.2.2.

The ON-OFF switch shall not be incorporated in the lamp holder or in the flexible connecting cords.

Stroboscopic effects from lights shall be avoided by the selection of appropriate luminaires.

15.2.2 Supply

The nominal voltage of the local lighting circuit shall not exceed 250 V between conductors. A voltage not exceeding 50 V between conductors is recommended.

Lighting circuits shall be supplied from one of the following sources (see also 7.2.6):

- a dedicated isolating transformer connected to the load side of the crane-disconnector. Overcurrent protection shall be provided in the secondary circuit;
- a dedicated isolating transformer connected to the line side of the crane-disconnector. That source shall be permitted for maintenance lighting circuits in control enclosures only. Overcurrent protection shall be provided in the secondary circuit (see also 5.3.8 ~~and 13.1.3~~);
- a circuit of the electrical equipment of the hoisting machine ~~circuit~~ for lighting with dedicated overcurrent protection;
- an isolating transformer connected to the line side of the supply disconnecting device, provided with a dedicated primary disconnecting means (see 5.3.5) and secondary overcurrent protection, and mounted within the control enclosure adjacent to the supply disconnecting device;
- an externally supplied lighting circuit (e.g. factory lighting supply). This shall be permitted in control enclosures only, and for the hoisting machine work light(s) where their total power rating is not more than 3 kW;
- power supply units, for DC supply to LED light sources, fitted with isolating transformers (for example, in accordance with IEC 61558-2-6).

Exception: Where fixed lighting is out of reach of operators during normal operations, the provisions of 15.2.2 do not apply.

15.2.3 Protection

Local lighting circuits shall be protected in accordance with 7.2.6.

15.2.4 Fittings

Adjustable lighting fittings shall be suitable for the physical environment.

The lampholders shall be

- in accordance with the relevant IEC standard;
- constructed with an insulating material protecting the lamp cap so as to prevent unintentional contact.

Reflectors shall be supported by a bracket and not by the lampholder.

Exception: Where fixed lighting is out of reach of operators during normal operation, the provisions of 15.2.4 do not apply.

16 Marking, warning signs and reference designations

16.1 General

Warning signs, nameplates, markings, labels and identification plates shall be of sufficient durability to withstand the physical environment involved.

16.2 Warning signs

16.2.1 Electric shock hazard

Enclosures that do not otherwise clearly show that they contain electrical equipment that can give rise to a risk of electric shock shall be marked with the graphical symbol ~~IEC 60417-5036 (2002-10)~~ ISO 7010-W012 (2011-05) (see Figure 23).

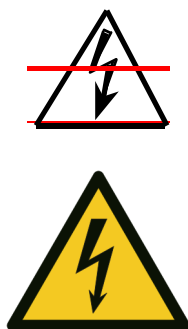


Figure 23 – Symbol ISO 7010-W012

The warning sign shall be plainly visible on the enclosure door or cover.

The warning sign may be omitted (see also 6.2.2 b)) for

- an enclosure equipped with the crane-supply-switch and the crane-disconnector;
- an operator-machine interface or control station;
- a single device with its own enclosure (e.g. position sensor).

16.2.2 Hot surfaces hazard

Where the risk assessment shows the need to warn against the possibility of hazardous surface temperatures of the electrical equipment, the graphical symbol ~~IEC 60417-5041 (2002-10)~~ ISO 7010-W017 (2011-05) shall be used (see Figure 24).

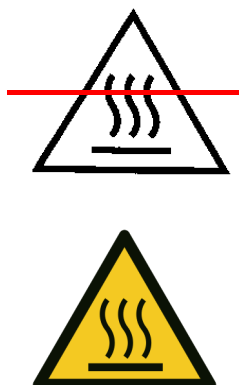


Figure 24 – Symbol ISO 7010-W017

NOTE ISO 13732-1 gives guidance for the assessment of the risks of burns when humans touch hot surfaces with their unprotected skin.

16.2.3 Hazard from energy storage system 36

Where the equipment includes an energy storage system (battery, super capacitor, etc.) and hazardous voltages may be present after disconnection of power supply, a durable warning sign shall be provided. shows a suitable warning sign that includes graphical symbols ISO 7010-W001 (2011-05) and ISO 7010-W012 (2011-05).



Figure 25 – Warning sign: energy storage system

16.3 Functional identification

Control devices and visual indicators, ~~and displays (particularly those related to safety) forming part of the operator machine interface~~ shall be clearly and durably marked with regard to their functions either on, or adjacent to the item. Such markings may be as agreed between the user and the supplier of the equipment ~~(see Annex B)~~. It is recommended that ~~standard symbols given in IEC 60417-2002 and ISO 7000 are used~~ such markings are in accordance with IEC 60417 and ISO 7000.

16.4 Marking of enclosures of electrical equipment

~~Equipment shall be legibly and durably marked in a way that is plainly visible after the equipment is installed.~~

~~Wherever possible (for example, on controlgear assemblies), a nameplate giving the following information shall be attached to the enclosure:~~

- ~~— name or trade mark of supplier;~~
- ~~— certification mark, when required;~~
- ~~— serial number, where applicable;~~
- ~~— rated voltage, number of phases and frequency (if a.c.), and rated current;~~
- ~~— short-circuit rating of the equipment;~~
- ~~— main document number (see IEC 62023).~~

~~The rated current shown on the nameplate shall be not less than the running currents for all motors and other equipment that can be in operation at the same time under normal conditions. Where there are unusual loads or duty cycles, the thermal equivalent current (see Annex D) shall be specified on the nameplate.~~

The following information shall be legibly and durably marked in a way that is plainly visible after the equipment is installed on enclosures that receive external incoming power supplies: **37**

- name or trade mark of supplier;
- type designation or model, where applicable;
- serial number, where applicable;
- main document number (see IEC 62023), where applicable;
- rated voltage, number of phases and frequency (if AC), and rated current for each incoming supply.

It is recommended that this information is provided adjacent to the main incoming supply or supplies.

Where only a single motor controller is used, that information may instead be provided on the hoisting machine nameplate where it is plainly visible. For a hoisting machine with more than one motion drive, such nameplates may be replaced by the relevant documentation.

Exception: Other enclosures of the same electrical equipment that are connected to a main switchgear or to other panels shall bear at least the following information:

- name or trade mark of supplier;
- type designation or designation reference according the documentation provided (electrical drawings or schematics);
- serial number, where applicable and if not already included in the designation reference.

16.5 Reference designations

All enclosures, assemblies, control devices, and components shall be plainly identified with the same reference designation as shown in the technical documentation.

Exception: Hoisting machines, on which the equipment comprises only a single motor, motor-controller, push-button station(s) and work light(s), need not conform to 16.5.

17 Technical documentation **38**

17.1 General

The information necessary for installation, operation, and maintenance of the electrical equipment of a hoisting machine shall be supplied in the appropriate forms, for example, drawings, diagrams, charts, tables, instructions. The information shall be in an agreed language (see also Annex B). ~~The information provided may vary with the complexity of the electrical~~

~~equipment. For very simple equipment, the relevant information may be contained in one document, provided that the document shows all the devices of the electrical equipment and enables the connections to the supply network to be made.~~

~~NOTE 1 The technical documentation provided with items of electrical equipment can form part of the documentation of the electrical equipment of the hoisting machine.~~

NOTE 1 Documentation is sometimes supplied in paper form, since it cannot be assumed that the user has access to the means of reading instructions supplied in electronic form or made available on an Internet site. However, it is often useful for the documentation to be made available in electronic form and on the Internet as well as in paper form, since this enables the user to download the electronic file and to recover the documentation if the paper copy has been lost. This practice also facilitates the updating of the documentation when this is necessary.

NOTE 2 In some countries, the requirement to use specific language(s) is covered by legal requirements.

Annex H should be considered as guidance for the preparation of information and documents.

~~17.2 Information to be provided~~

~~The information provided with the electrical equipment shall include~~

- ~~a) a main document (parts list or list of documents);~~
- ~~b) complementary documents including:~~
 - ~~1) a clear, comprehensive description of the equipment, installation and mounting, and the connection to the electrical supply(ies);~~
 - ~~2) electrical supply(ies) requirements;~~
 - ~~3) information on the physical environment (for example, lighting, vibration, atmospheric contaminants) where appropriate;~~
 - ~~4) overview (block) diagram(s) where appropriate;~~
 - ~~5) circuit diagram(s);~~
 - ~~6) information (as applicable) on~~
 - ~~— programming, as necessary for use of the equipment;~~
 - ~~— sequence of operation(s);~~
 - ~~— frequency of inspection;~~
 - ~~— frequency and method of functional testing;~~
 - ~~— guidance on the adjustment, maintenance, and repair, particularly of the protective devices and circuits; and~~
 - ~~— recommended spare parts list~~
 - ~~— list of tools supplied.~~
 - ~~7) a description (including interconnection diagrams) of the safeguards, interlocking functions, and interlocking of guards against hazards, particularly for hoisting machines operating in a coordinated manner;~~
 - ~~8) a description of the safeguarding and of the means provided where it is necessary to suspend the safeguarding (for example, for setting or maintenance) (see 9.2.4);~~
 - ~~9) instructions on the procedures for securing the hoisting machine for safe maintenance; (see also 17.8);~~
 - ~~10) information on handling, transportation and storage;~~
 - ~~11) information regarding load currents, peak starting currents and permitted voltage drops, as applicable;~~
 - ~~12) information on the residual risks due to the protection measures adopted, indication of whether any particular training is required and specification of any necessary personal protective equipment.~~

17.3 Requirements applicable to all documentation

Unless otherwise agreed between manufacturer and user:

- the documentation shall be in accordance with IEC 61082-1;
- reference designations shall be in accordance with relevant parts of IEC 61346;
- instructions/manuals shall be in accordance with IEC 62079;
- parts lists where provided shall be in accordance with IEC 62027, class B.

NOTE See item 13 of Annex B.

For referencing of the different documents, the supplier shall select one of the following methods:

- Where the documentation consists of a small number of documents (for example, less than five) each of the documents shall carry as a cross-reference, the document numbers of all other documents belonging to the electrical equipment.
- For single-level main documents only (see IEC 62023), all documents shall be listed with document numbers and titles in a drawing or document list; or
- All documents of a certain level (see IEC 62023) of the document structure shall be listed, with document numbers and titles, in a parts list belonging to the same level.

17.4 Installation documents

The installation documents shall give all information necessary for the preliminary work of setting up the hoisting machine (including commissioning). In complex cases, it may be necessary to refer to the assembly drawings for details.

The recommended position, type, and cross-sectional areas of the supply cables to be installed on site shall be clearly indicated.

The data necessary for choosing the type, characteristics, rated currents, and setting of the overcurrent protective device(s) for the supply conductors to the electrical equipment of the hoisting machine shall be stated (see 7.2.2).

Where necessary, the size, purpose, and location of any ducts in the foundation that are to be provided by the user shall be detailed (see Annex B).

The size, type, and purpose of ducts, cable trays, or cable supports between the hoisting machine and the associated equipment that are to be provided by the user shall be detailed (see Annex B).

Where necessary, the diagram shall indicate where space is required for the removal or servicing of the electrical equipment.

NOTE 1 Examples of installation diagrams can be found in IEC 61082-1.

In addition, where it is appropriate an interconnection diagram or table shall be provided. That diagram or table shall give full information about all external connections. Where the electrical equipment is intended to be operated from more than one source of electrical supply, the interconnection diagram or table shall indicate the modifications or interconnections required for the use of each supply.

NOTE 2 Examples of interconnection diagrams/tables can be found in IEC 61082-1.

17.5 Overview diagrams and function diagrams

Where it is necessary to facilitate the understanding of the principles of operation, an overview diagram shall be provided. An overview diagram symbolically represents the electrical

~~equipment together with its functional interrelationships without necessarily showing all of the interconnections.~~

~~NOTE 1—Examples of overview diagrams can be found in IEC 61082-1.~~

~~Function diagrams may be provided as either part of, or in addition to, the overview diagram.~~

~~NOTE 2—Examples of function diagrams can be found in IEC 61082-1.~~

17.6—Circuit diagrams

~~A circuit diagram(s) shall be provided. This diagram(s) shall show the electrical circuits on the hoisting machine and its associated electrical equipment. Any graphical symbol not shown in IEC 60617:2001 shall be separately shown and described on the diagrams or supporting documents. The symbols and identification of components and devices shall be consistent throughout all documents and on the hoisting machine.~~

~~Where appropriate, a diagram showing the terminals for interface connections shall be provided. That diagram may be used in conjunction with the circuit diagram(s) for simplification. The diagram should contain a reference to the detailed circuit diagram of each unit shown.~~

~~Switch symbols shall be shown on the electromechanical diagrams with all supplies turned off (for example, electricity, air, water, lubricant) and with the hoisting machine and its electrical equipment ready for a normal start.~~

~~Conductors shall be identified in accordance with 13.2.~~

~~Circuits shall be shown in such a way as to facilitate the understanding of their function as well as maintenance and fault location. Characteristics relating to the function of the control devices and components which are not evident from their symbolic representation shall be included on the diagrams adjacent to the symbol or referenced to a footnote.~~

17.7—Operating manual

~~The technical documentation shall contain an operating manual detailing proper procedures for set-up and use of the electrical equipment. Particular attention should be given to the safety measures provided.~~

~~Where the operation of the equipment can be programmed, detailed information on methods of programming, equipment required, programme verification, and additional safety procedures (where required) shall be provided.~~

17.8—Maintenance manual

~~The technical documentation shall contain a maintenance manual detailing proper procedures for adjustment, servicing and preventive inspection, and repair. Recommendations on maintenance/service intervals and records should be part of that manual. Where methods for the verification of proper operation are provided (for example, software testing programmes), the use of those methods shall be detailed.~~

~~The description of how to make settings of programmable equipment (for example, motor drive systems) shall contain clear references to the final functions of the hoisting machine. The testing of the safety-related functions shall be clearly specified.~~

17.9—Parts list

~~The parts list, where provided, shall comprise, as a minimum, information necessary for ordering spare or replacement parts (for example, components, devices, software, test~~

~~equipment, technical documentation) required for preventive or corrective maintenance including those that are recommended to be carried in stock by the user of the equipment.~~

~~The parts list shall show for each item~~

- ~~— the reference designation used in the documentation;~~
- ~~— its type designation;~~
- ~~— the supplier and alternative sources where available;~~
- ~~— its main characteristics, where appropriate.~~

17.2 Information related to the electrical equipment

The following shall be supplied:

- a) where more than one document is provided, a main document for the electrical equipment as a whole, listing the complementary documents associated with the electrical equipment;
- b) identification of the electrical equipment (see 16.4);
- c) information on installation and mounting including:
 - a description of the electrical equipment's installation and mounting, and its connection to the electrical supplies and where relevant other supplies;
 - short-circuit current rating of the electrical equipment for each incoming power supply;
 - rated voltage, number of phases and frequency (if AC), type of distribution system (TT, TN, IT) and full-load current for each incoming supply;
 - any additional electrical supply requirements (for example maximum supply source impedance, leakage current) for each incoming supply;
 - space required for the removal or servicing of the electrical equipment;
 - installation requirements where needed to ensure that the arrangements for cooling are not impaired;
 - environmental limitations (for example lighting, vibration, EMC environment, atmospheric contaminants) where appropriate;
 - functional limitations (for example peak starting currents and permitted voltage drop(s)) as applicable;
 - precautions to be taken for the installation of the electrical equipment relevant to the electromagnetic compatibility;
- d) an instruction for the connection of simultaneously accessible extraneous conductive parts in the vicinity of the machine (for example, within 2,5 metres) such as the following to the protective bonding circuit:
 - metallic pipes;
 - fences;
 - ladders;
 - handrails.
- e) information on the functioning and operation, including as applicable:
 - an overview of the structure of the electrical equipment (for example by structure diagram or overview diagram);
 - procedures for programming or configuring, as necessary for the intended use;
 - procedures for restarting after an unexpected stop;
 - a sequence of operation;
- f) information on maintenance and periodic tests of the electrical equipment, as appropriate, including:
 - frequency and method of functional testing and measurements;

- instructions on the procedures for safe maintenance and where it is necessary to suspend a safety function and/or protective measure (see 9.2.4);
 - guidance on the adjustment, repair, and frequency and method of preventive maintenance;
 - details of the interconnections of the electrical components subject to replacement (for example by circuit diagrams and/or connection tables);
 - information on required special devices or tools;
 - information on spare parts;
 - information on possible residual risks, indication of whether any particular training is required and specification of any necessary personal protective equipment;
 - where applicable, instructions to restrict availability of key(s) or tool(s) to skilled or instructed persons only;
 - settings (DIP-switches, programmable parameter values, etc);
 - information for validation of safety related control functions after repair or modification, and for periodic testing where necessary;
- g) information on handling, transportation and storage as appropriate (for example dimensions, weight, environmental conditions, possible ageing constraints);
- h) information for proper disassembly and handling of components (for example for recycling or disposal).

18 Verification

18.1 General

Clause 18 gives general requirements for the verification of the electrical equipment of hoisting machines.

The extent of verification for a particular hoisting machine type will be given in the dedicated product standard. ~~The verifications shall always include the items c), a), b), f), and e) or d) or both, and may include item e)~~ Where there is no dedicated product standard for the machine, the verifications shall always include the items a), b), c), d) and h) and may include one or more of the items e) to g):

- a) verification that the electrical equipment complies with its technical documentation;
- b) verification of continuity of the protective bonding circuit (Test 1 of 18.2.2);
- c) in case of fault protection ~~against indirect contact~~ by automatic disconnection of supply, verification of the conditions for protection by automatic disconnection (see 18.2);
- d) insulation resistance test (see 18.3);
- e) voltage test (see 18.4);
- f) protection against residual voltage (see 18.5);
- g) verification that the relevant requirements of 8.2.8 are met;
- h) functional tests (see 18.6).

When these tests are performed, it is recommended that they follow the sequence listed above. Where the sequence cannot be followed, verification a) and b) shall be conducted first.

When the electrical equipment is modified, the requirements specified in 18.7 shall apply.

~~NOTE – For tests in accordance with 18.2 and 18.3, measuring equipment in accordance with the IEC 61557 series is applicable. For other tests required by this standard, measuring equipment in accordance with relevant IEC or European standards should be used.~~

For verifications that include measurement, measuring equipment in accordance with IEC 61557 (all parts) is recommended.

The results of the verification shall be documented.

18.2 Verification of conditions for protection by automatic disconnection of supply

18.2.1 General

The conditions for automatic disconnection of supply (see 6.3.3) shall be verified by tests.

Test 1 verifies the continuity of the protective bonding circuit.

Test 2 verifies the conditions for protection by automatic disconnection of the supply in TN systems.

For TN-systems, those test methods are described in 18.2.2 and 18.2.3; their application for different conditions of supply are specified in 18.2.4.

~~For TT and IT systems, see IEC 60364-6.~~

For TT systems, see Clause A.2.

IT systems, see IEC 60364-6:2016.

Where RCDs are used in the electrical equipment, their function shall be verified in accordance with the manufacturer's instructions. The test procedure and test interval shall be specified in the maintenance instructions.

~~18.2.2 Test methods in TN systems~~

~~Test 1 verifies the continuity of the protective bonding circuit. Test 2 verifies the conditions for protection by automatic disconnection of the supply.~~

18.2.2 Test 1 – Verification of the continuity of the protective bonding circuit

The resistance ~~of each protective bonding circuit~~ between the PE terminal (see 5.2 and Figure 4) and relevant points that are part of ~~each~~ the protective bonding circuit shall be measured with a current, between at least 0,2 A and approximately 10 A derived from an electrically separated supply source (for example SELV, see Clause 414 of IEC 60364-4-41:2005) having a maximum no-load voltage of 24 V AC or DC.

The resistance measured shall be in the expected range according to the length, the cross-sectional area and the material of the related protective conductors and protective bonding conductor(s).

Earthed PELV supplies can produce misleading results in this test and therefore shall not be used.

NOTE Larger currents used for the continuity test increase the accuracy of the test result, especially with low resistance values, i.e. larger cross-sectional areas and/or lower conductor lengths.

18.2.3 Test 2 – Fault loop impedance verification and suitability of the associated overcurrent protective device

The connections of ~~the~~ each power supply ~~and~~ including the connection of the ~~incoming~~ associated external protective conductor to the PE terminal of the hoisting machine, shall be verified by inspection.

The conditions for the protection by automatic disconnection of supply in accordance with 6.3.3 and Annex A shall be verified by both

- a) verification of the fault loop impedance by
 - calculation, or
 - measurement in accordance with A.1.4, or A.2.4 for TT-systems; and
- b) confirmation that the setting and characteristics of the associated overcurrent protective device are in accordance with the requirements of Annex A and where a power drive system (PDS) is used, confirmation that the setting and characteristics of the protective device(s) associated with a PDS are in accordance with the converter manufacturer's and protective device manufacturer's instructions.

NOTE Fault loop impedance can be measured for circuits where the conditions of protection by automatic disconnection require a current I_a up to about 1 kA (I_a is the current causing the automatic operation of the disconnecting device within the time specified in Annex A).

18.2.4 Application of the test methods for TN-systems

Each protective bonding circuit of a hoisting machine shall be tested in accordance with Test 1 of 18.2.2.

When Test 2 of 18.2.3 is carried out by measurement, it shall always be preceded by Test 1.

NOTE A discontinuity of the protective bonding circuit can cause a hazardous situation for the tester or other persons, or damage to the electrical equipment during the loop impedance test.

The tests that are necessary for hoisting machines of different status are specified in Table 10.

~~Table 11 can be used to enable determination of the hoisting machine status.~~

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Table 10 – Application of the test methods for TN-systems

Procedure	~~Hoisting~~ Machine status	Verification on site
A	Electrical equipment of ~~hoisting~~ machines, erected and connected on site, where the continuity of the protective bonding circuits has not been confirmed following erection and connection on site.	Test 1 (see 18.2.2) and Test 2 (see 18.2.3) Exception: Test 2 is not required where: - test 1 is performed on the protective bonding conductors of the machine that are connected on site; and - the connections of each incoming power supply and of the associated protective conductor (PE) to the PE-terminal of the machine, are verified by inspection, and ~~if~~ previous calculations of the fault loop impedance (or resistance) by the manufacturer of the electrical equipment are available; and ~~where~~ - the arrangement of the installations permits the verification of the length and cross-sectional area of the conductors used for the calculation; and - it can be confirmed through calculation or measurement, or by information supplied by the customer, that the supply source impedance on site ~~is less than, or equal to, that of the supply used for the value assumed for the calculation by the manufacturer~~ does not exceed the value specified by the manufacturer of the electrical equipment. See 17.2 c), fourth bullet). ~~Test 1 (see 18.2.2) of the protective bonding circuits connected on site and verification by inspection of the connections of the power supply and of the incoming external protective conductor to the PE terminal of the hoisting machine is sufficient~~
B	~~Hoisting~~ Machine supplied with confirmation of the verification (see 18.1) of continuity of the protective bonding circuits by test 1 or with the results of a test 2 by measurement, having protective bonding circuits exceeding the cable length for which examples are given in ~~Table 11~~ Table 9.	Test 2 (see ~~18.2.2~~ 18.2.3) Exception: Where it can be confirmed through calculation or measurement, or by information supplied by the customer, that the supply source impedance on site ~~is less than, or equal to, that used for the calculation~~ does not exceed the value specified by the manufacturer of the electrical equipment, or that of the test supply during a test 2 by measurement, no test is required on site apart from verification of the connections:
	Case B1) supplied fully assembled and not dismantled for shipment,	in case B1) of each incoming power supply and of the ~~incoming external~~ associated protective conductor to the PE terminal of the ~~hoisting~~ machine;
	Case B2) supplied dismantled for shipment, where the continuity of protective conductors is ensured after dismantling, transportation and reassembly (for example by the use of plug/socket connections).	in case B2) of each incoming power supply and of the ~~incoming external~~ associated protective conductor to the PE terminal of the ~~hoisting~~ machine and of all connections of the protective conductor(s) that were disconnected for shipment.
C	~~Hoisting~~ Machine having protective bonding circuits not exceeding the cable length for which examples are given in ~~Table 11~~ Table 10, supplied with confirmation of the verification (see 18.1) of continuity of the protective bonding circuits by test 1 ~~or Test 2 (see 18.2.2) by measurement.~~ Case C1) supplied fully assembled and not dismantled for shipment.	For case C1 or C2, no test is required on site. For a ~~hoisting~~ machine not connected to the power supply by a plug/socket combination, the correct connection of the ~~incoming~~ external protective conductor to the PE-terminal of the ~~hoisting~~ machine shall be verified by visual inspection.

	Case C2) supplied dismantled for shipment, where the continuity of protective conductors is ensured after dismantling, transportation and reassembly (for example by the use of plug/socket combination(s)).	In case C2), the installation documents (see 17.4 17.2) shall require that all connections of the protective conductor(s) that were disconnected for shipment are verified, for example by visual inspection.

Examples of maximum cable length from each protective device to their loads for TN-systems are shown in Table 11.

Table 11 – Examples of maximum cable length from each protective device to ~~its~~ their loads for TN-systems 39

1 Supply source impedance to each protective device	2 Cross- sectional area	3 Nominal rating or setting of the protective device I_N	4 Fuse disconnect time 5 s	5 Fuse disconnect time 0,4 s	6 Miniature circuit- breaker char. B ¹ $I_a = 5 \times I_N$ disconnect time 0,1 s	7 Miniature circuit- breaker char. C ² $I_a = 10 \times I_N$ disconnect time 0,1 s	8 Adjustable circuit-breaker $I_a = 8 \times I_N$ disconnect time 0,1 s
mΩ	mm ²	A	Maximum cable length in m from each protective device to its load				
500	1,5	16	97	53	76	30	28
500	2,5	20	115	57	94	34	36
500	4,0	25	135	66	114	35	38
400	6,0	32	145	59	133	40	42
300	10	50	125	41	132	33	37
200	16	63	175	73	179	55	61
200	25 (line)/16 (PE)	80	133				38
100	35 (line)/16 (PE)	100	136				73
100	50 (line)/25 (PE)	125	141				66
100	70 (line)/35 (PE)	160	138				46
50	95 (line)/50 (PE)	200	152				98
50	120 (line)/70 (PE)	250	157				79

The values of the maximum cable length in Table 11 are based on the following assumptions:

- PVC cable with copper conductors, conductor temperature under short circuit conditions 160 °C (see Table C.4);
- cables with line conductors up to 16 mm² provide a protective conductor of equal cross sectional area to that of the line conductors;
- cables above 16 mm² provide a reduced size protective conductor as shown;
- 3 phase system, nominal voltage of the power supply 400 V;
- maximum supply source impedance to each protective device in accordance with column 1;
- column 3 values are correlated with Table 7 (see 12.4).

A deviation from these assumptions can require a complete calculation or measurement of the fault loop impedance. Further information is available from IEC 60228 and IEC/TR 61200-53.

¹ In accordance with the IEC 60898 series.

² In accordance with the IEC 60898 series.

1	2	3	4	5	6	7	8	9
Maximum source impedance of the supply to the protective device	Minimum cross-sectional area	Maximum nominal rating or setting of the protective device I_N	Fuse disconnect time 5 s	Fuse disconnect time 0,4 s	Miniature circuit-breaker char.B $I_a = 5 \times I_N$	Miniature circuit-breaker char.C $I_a = 10 \times I_N$	Miniature circuit-breaker char.D $I_a = 20 \times I_N$	Adjustable circuit-breaker $I_a = 8 \times I_N$
mΩ	mm ²	A	Maximum cable length in metres from each protective device to its load					
500	1,5	16	97	53	76	30	7	31
500	2,5	20	115	57	94	34	3	36
500	4,0	25	135	66	114	35		38
400	6,0	32	145	59	133	40		42
300	10	50	125	41	132	33		37
200	16	63	175	73	179	55		61
200	25 (line)/ 16 (PE)	80	133					38
100	35 (line)/ 16 (PE)	100	136					73
100	50 (line)/ 25 (PE)	125	141					66
100	70 (line)/ 35 (PE)	160	138					46
50	95 (line)/ 50 (PE)	200	152					98
50	120 (line)/ 70 (PE)	250	157					79

The values of the maximum cable length in Table 11 are based on the following assumptions:

- PVC cable with copper conductors, conductor temperature under short-circuit conditions 160 °C (see Table C.5);
- cables with line conductors up to 16 mm² provide a protective conductor of equal cross sectional area to that of the line conductors;
- cables above 16 mm² provide a reduced size protective conductor as shown;
- 3-phase system, nominal voltage of the power supply 400 V ($U_0 = 230$ V);
- column 3 values are correlated with Table 7 (see 12.4);
- disconnection time for circuit-breakers is $\leq 0,4$ s (columns 6 to 9).

NOTE A deviation from these assumptions can require a complete calculation or measurement of the fault loop impedance. Further information is available from IEC 60228 and IEC TS 61200-53.

18.3 Insulation resistance tests

When insulation resistance tests are performed, the insulation resistance measured at 500 V DC between the power circuit conductors and the protective bonding circuit shall be not less than 1 MΩ. The test may be made on individual sections of the complete electrical installation.

Exception: For certain parts of electrical equipment, incorporating, for example, busbars, conductor wire or conductor bar systems or slip-ring assemblies, a lower minimum value is permitted, but that value shall not be less than 50 kΩ.

If the electrical equipment of the hoisting machine contains surge protection devices which are likely to operate during the test, it is permitted to either

- disconnect these devices; or
- reduce the test voltage to a value lower than the voltage protection level of the surge protection devices, but not lower than the peak value of the upper limit of the supply (phase-to-neutral) voltage.

18.4 Voltage tests

~~When voltage tests are performed, test equipment in accordance with IEC 61180-2 should be used.~~

The test voltage shall be at a nominal frequency of 50 Hz or 60 Hz.

The maximum test voltage shall have a value of twice the rated supply voltage of the equipment or 1 000 V, whichever is the greater. The maximum test voltage shall be applied between the power circuit conductors and the protective bonding circuit for ~~a period of approximately~~ at least 1 s. The requirements are satisfied if no disruptive discharge occurs.

Components and devices that are not rated to withstand the test voltage and surge protection devices which are likely to operate during the test shall be disconnected before testing.

Components and devices that have been voltage tested in accordance with their product standards may be disconnected during testing.

NOTE Test equipment in accordance with IEC 61180 or IEC 61557-14 can be used to perform voltage testing.

18.5 Protection against residual voltages

Where appropriate, tests shall be performed to ensure compliance with 6.2.4.

18.6 Functional tests

The functions of electrical equipment shall be tested, particularly those related to safety and safeguarding. Where a function cannot be fully tested, the circuit(s) shall be tested.

18.7 Retesting

Where a portion of the hoisting machine and its associated equipment is changed or modified, ~~that portion shall be reverified and retested, as appropriate (see 18.1)~~ the need for re-verification and testing of the electrical equipment shall be considered.

Particular attention should be given to the possible adverse effects that retesting can have on the equipment (e.g. overstressing of insulation, disconnection/reconnection of devices).

Annex A **(normative)**

Protection against indirect contact in TN systems

(Derived from IEC 60364-4-41 and IEC 60364-6)

A.1 General

Protection against indirect contact shall be provided by an overcurrent protective device that automatically disconnects the supply to the circuit or equipment in the event of a fault between a live part and an exposed conductive part or a protective conductor in the circuit or equipment, within a sufficiently short disconnecting time. A disconnecting time not exceeding 5 s is considered sufficiently short for hoisting machines.

Exception: Where this disconnecting time cannot be assured, measures shall be implemented (for example, supplementary protective bonding) to prevent a prospective touch voltage from exceeding 50 V a.c. or 120 V ripple-free d.c. between simultaneously accessible conductive parts. See Clause A.3.

For circuits which supply, through socket outlets or direct without socket outlets, Class I hand-held equipment or portable equipment (for example, socket outlets on a hoisting machine for accessory equipment; see 15.1), Table A.1 specifies the maximum disconnecting times that are considered sufficiently short.

Table A.1 – Maximum disconnecting times for TN systems

U_0^a V	Disconnecting time s
120	0,8
230	0,4
277	0,4
400	0,2
>400	0,1

^a U_0 is the nominal a.c. r.m.s. voltage to earth. For voltages which are within the tolerance band stated in IEC 60038, the disconnecting time appropriate to the nominal voltage applies. For intermediate values of voltage, the next higher value in the above table is to be used.

A.2 Conditions for protection by automatic disconnection of the supply by overcurrent protective devices

The characteristics of overcurrent protective devices and the circuit impedances shall be such that, if a fault of negligible impedance occurs anywhere in the electrical equipment between a phase conductor and a protective conductor or exposed conductive part, automatic disconnection of the supply will occur within the specified time (i.e., ≤5 s or ≤ values in accordance with Table A.1). The following condition fulfils this requirement:

$$Z_s \times I_a \leq U_0$$

where

Z_e is the impedance of the fault loop comprising the source, the live conductor up to the point of the fault and the protective conductor between the point of the fault and the source;

I_a is the current causing the automatic operation of the disconnecting protective device within the specified time;

U_0 is the nominal a.c. voltage to earth.

The increase of the resistance of the conductors with the increase of temperature due to the fault current shall be taken into account (see A.4.3).

NOTE Information for calculating short-circuits current can be found in, for example, the IEC 60909 series or from suppliers of short-circuit protective devices.

A.3 Condition for protection by reducing the touch voltage below 50 V

Where the requirements of Clause A.2 cannot be assured and supplementary bonding is selected as the means of ensuring protection against hazardous touch voltages, the condition for this protection is that the touch voltage has been reduced to below 50 V and it is achieved when the impedance of the protective circuit (Z_{PE}) does not exceed:

$$Z_{PE} < \frac{50}{U_0} \times Z_s$$

where Z_{PE} is the impedance of the protective bonding circuit between the equipment anywhere in the installation and the PE terminal of the hoisting machine (see 5.2 and Figure 3) or between simultaneously accessible exposed conductive parts and/or extraneous conductive parts

Confirmation of this condition can be achieved by using the method of Test 1 of 18.2.2 to measure the resistance R_{PE} . The condition for protection is achieved when the measured value of R_{PE} does not exceed:

$$R_{PE} < \frac{50}{I_{a(5s)}}$$

where

$I_{a(5s)}$ is the 5 s operating current of the protective device;

R_{PE} is the resistance of the protective bonding circuit between the PE terminal (see 5.2 and Figure 4) and the equipment anywhere on the hoisting machine, or between simultaneously accessible exposed conductive parts and/or extraneous conductive parts.

NOTE 1 Supplementary protective bonding is considered as an addition to protection against indirect contact.

NOTE 2 Supplementary protective bonding may involve the entire installation, a part of the installation, an item of apparatus, or a location.

A.4 Verification of conditions for protection by automatic disconnection of the supply

A.4.1 General

The effectiveness of the measures for protection against indirect contact by automatic disconnection of supply in accordance with Clause A.2 is verified as follows.

- Verification of the characteristics of the associated protective device by visual inspection of the nominal current setting for circuit-breakers and the current rating for fuses.
- Measurement of the fault loop impedance (Z_e).

Exception: Where the calculations of the fault loop impedance or of the resistance of the protective conductors are available and when the arrangement of the installations permits the verification of the length and cross-sectional area of the conductors, verification of the continuity of the protective conductors may replace the measurement.

A.4.2 — Measurement of the fault loop impedance

Measurement of the fault loop impedance shall be performed using measuring equipment that complies with IEC 61557-3. The information about the accuracy of the measuring results, and the procedures to be followed given in the documentation of the measuring equipment shall be considered.

Measurement shall be performed when the hoisting machine is connected to a supply having the same frequency as the nominal frequency of the supply at the intended installation.

NOTE 1 Figure A.1 illustrates a typical arrangement for measuring the fault loop impedance on a machine. If it is not practicable for the motor to be connected during the test, the two phase conductors not used in the test can be opened, for example, by removing fuses.

NOTE 2 The fault loop impedance measurement is usually only possible upstream from electronic converters, but not between the converter and motor (see IEC 61800-5-1). The motor "M" in Figure A.1 can be understood to represent a power drive system (PDS) in accordance with the IEC 61800 series.

The measured value of the fault loop impedance shall conform to Clause A.2.

A.4.3 — Consideration of the difference between the measured value of resistance of the conductors and the actual value under fault conditions

NOTE As the measurements are made at ambient temperature, with low currents, it is necessary to take into account the increase of resistance of the conductors with the increase of temperature under fault conditions, to verify the compliance of the measured value of the fault loop impedance with the requirements of Clause A.2.

The increase of resistance of the conductors with the increase of temperature due to the fault current is taken into account in the following equation:

$$\frac{Z_{s(m)}}{Z_s} \leq \frac{2}{3} \times \frac{U_0}{I_a}$$

where $Z_{s(m)}$ is the measured value of Z_s

Where the measured value of the fault loop impedance exceeds $2U_0/3I_a$, a more precise assessment can be made in accordance with the procedure described in C.61.3.6.2 of IEC 60364-6.

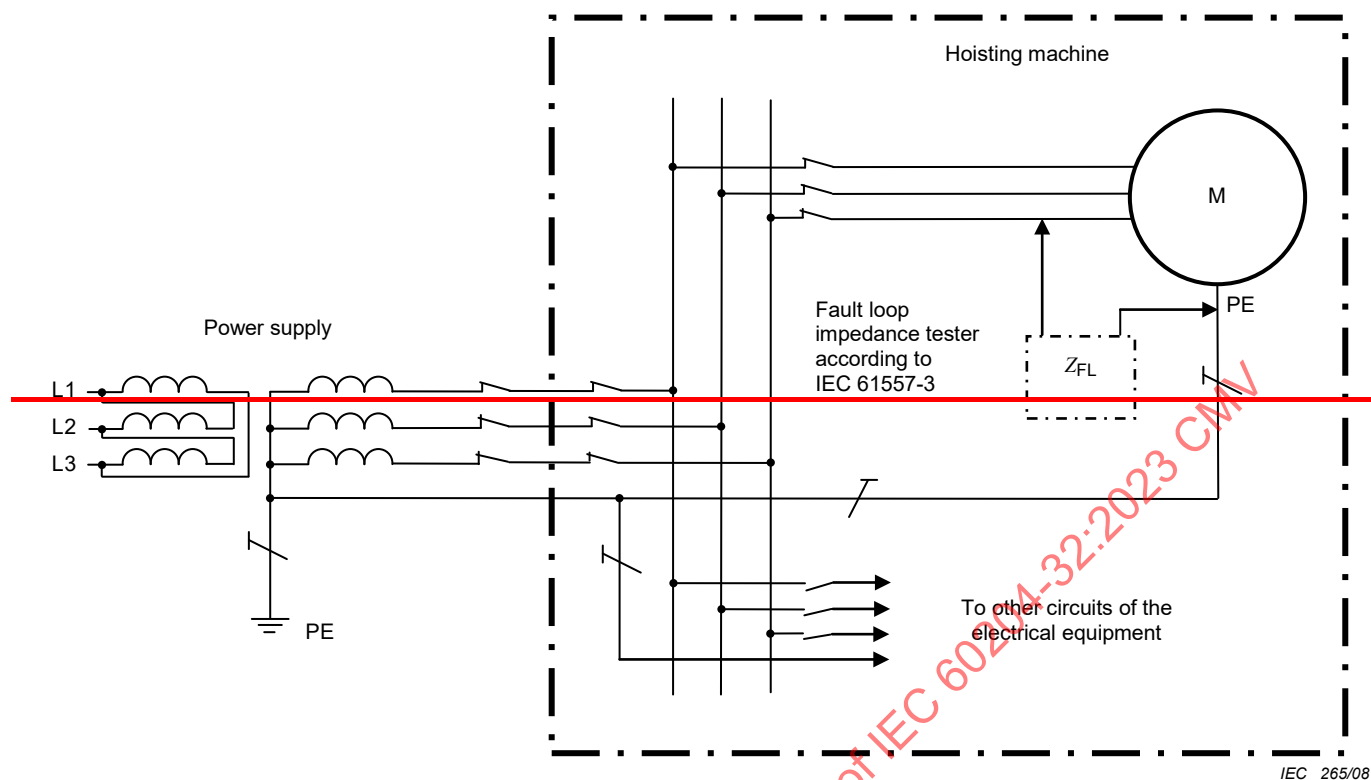


Figure A.1 – Typical arrangement for fault loop impedance measurement

Annex A (normative)

Fault protection by automatic disconnection of supply

A.1 Fault protection for machines supplied from TN-systems

A.1.1 General 40

The provisions in Annex A are derived from IEC 60364-4-41:2005, IEC 60364-4-41:2005/AMD1:2017, and IEC 60364-6:2016.

Fault protection shall be provided by an overcurrent protective device that automatically disconnects the supply to the circuit or equipment in the event of a fault between a live part and an exposed conductive part or a protective conductor in the circuit or equipment, within a sufficiently short disconnecting time. A disconnecting time not exceeding 5 s is considered sufficiently short for machines that are neither hand-held nor portable.

Where this disconnecting time cannot be assured, supplementary protective bonding shall be provided in accordance with A.1.3 that can prevent a prospective touch voltage from exceeding 50 V AC or 120 V ripple-free DC between simultaneously accessible conductive parts.

NOTE The use of supplementary protective bonding does not preclude the need to disconnect the supply for other reasons, for example protection against fire, thermal stresses in equipment, etc.

For circuits which supply, through socket-outlets or directly without socket-outlets, Class 1 hand-held equipment or portable equipment (for example socket-outlets on a machine for accessory equipment, see 15.1) Table A.1 specifies the maximum disconnecting times that are considered sufficiently short.

Table A.1 – Maximum disconnecting times for TN systems

System	Maximum disconnecting time							
	s							
	50 V < U ₀ ≤ 120 V		120 V < U ₀ ≤ 230 V		230 V < U ₀ ≤ 400 V		U ₀ > 400 V	
	AC	DC	AC	DC	AC	DC	AC	DC
TN	0,8	NOTE 1	0,4	5	0,2	0,4	0,1	0,1
U ₀ is the nominal AC or DC line-to-earth voltage.								
NOTE 1 Disconnection can be required for reasons other than protection against electric shock.								
NOTE 2 For voltages which are within the tolerance band stated in IEC 60038, the disconnecting time appropriate to the nominal voltage applies.								

A.1.2 Conditions for protection by automatic disconnection of the supply by overcurrent protective devices

The characteristics of overcurrent protective devices and the circuit impedances shall be such that, if a fault of negligible impedance occurs anywhere in the electrical equipment between a line conductor and a protective conductor or exposed conductive part, automatic disconnection of the supply will occur within the specified time (i.e. ≤ 5 s or less than or equal to the values in accordance with Table A.1). The following general condition fulfils this requirement:

$$Z_s \times I_a \leq U_0$$

where

Z_s is the impedance of the fault loop comprising the source, the live conductor up to the point of the fault and the protective conductor between the point of the fault and the source;

I_a is the current causing the automatic operation of the disconnecting protective device within the specified time;

U_0 is the nominal AC voltage to earth.

The increase of the resistance of the conductors with the increase of temperature due to the fault current shall be taken into account in the following equation:

$$Z_{s(n)} \leq \frac{2}{3} \times \frac{U_0}{I_a}$$

where $Z_{s(n)}$ is the measured or calculated value of Z_s under normal operating conditions.

NOTE Where the value of the fault loop impedance exceeds $2U_0/3I_a$, a more precise assessment can be made in accordance with the procedure described in D.6.4.3.7.3 of IEC 60364-6:2016.

A.1.3 Condition for protection by reducing the touch voltage below 50 V

Where the requirements of A.1.2 cannot be assured, supplementary protective bonding can be selected as the means of ensuring that touch voltages will not exceed 50 V. This is achieved when the impedance of the protective bonding circuit (Z_{PE}) does not exceed:

$$Z_{PE} \leq \frac{50}{U_0} \times Z_s$$

where Z_{PE} is the impedance of the protective bonding circuit between the equipment anywhere in the installation and the PE terminal of the machine (see 5.2 and Figure 6) or between simultaneously accessible exposed conductive parts and/or extraneous conductive parts.

Confirmation of this condition can be achieved by using the method of Test 1 of 18.2.2 to measure the resistance R_{PE} . The condition for protection is achieved when the measured value of R_{PE} does not exceed:

$$R_{PE} \leq \frac{50}{I_{a(5s)}}$$

where

$I_{a(5s)}$ is the 5 s operating current of the protective device;

R_{PE} is the resistance of the protective bonding circuit between the PE terminal (see 5.2 and Figure 6) and the equipment anywhere on the machine, or between simultaneously accessible exposed conductive parts and/or extraneous conductive parts.

NOTE 1 Supplementary protective bonding is considered as an addition to fault protection.

NOTE 2 Supplementary protective bonding can involve the entire installation, a part of the installation, an item of apparatus, or a location.

A.1.4 Verification of conditions for protection by automatic disconnection of the supply

A.1.4.1 General

The effectiveness of the measures for fault protection by automatic disconnection of supply in accordance with A.1.2 is verified as follows:

- verification of the characteristics of the associated protective device by visual inspection of the nominal current setting for circuit-breakers and the current rating for fuses; and
- measurement of the fault loop impedance (Z_s). See Figure A.1.

Exception: Verification of the continuity of the protective conductors may replace the measurement where the calculations of the fault loop impedance are available and when the arrangement of the installations permits the verification of the length and cross-sectional area of the conductors.

Where a power drive system (PDS) is used, the disconnection time for fault protection shall meet the relevant requirements of this Annex A at the incoming supply terminals of the basic drive module (BDM) of the PDS. See Figure A.2.

A.1.4.2 Measurement of the fault loop impedance

Where measurement of the fault loop impedance is performed, it is recommended that the measuring equipment comply with IEC 61557-3. The information about the accuracy of the measuring results, and the procedures to be followed given in the documentation of the measuring equipment shall be considered.

Measurement shall be performed when the machine is connected to a supply having the same frequency as the nominal frequency of the supply at the intended installation.

NOTE Figure A.1 illustrates a typical arrangement for measuring the fault loop impedance on a machine.

If it is not practicable for the motor to be connected during the test, the two line conductors not used in the test may be opened, for example, by removing fuses.

The measured value of the fault loop impedance shall be in accordance with A.1.2.

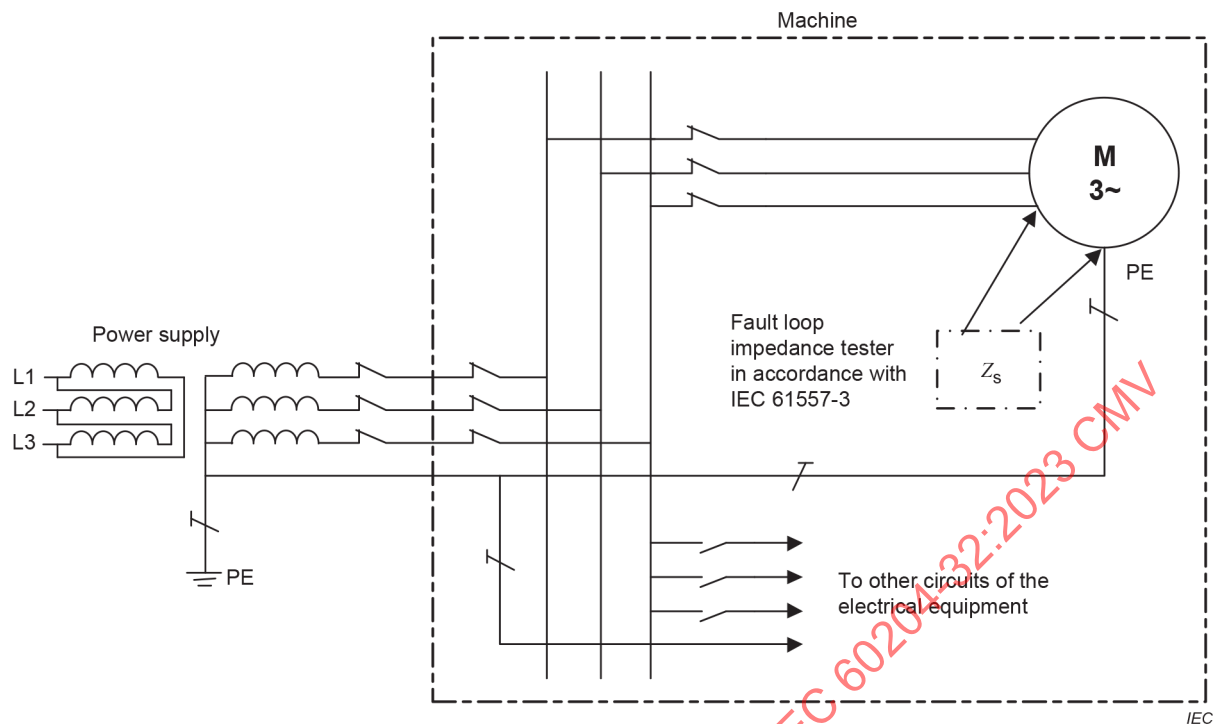


Figure A.1 – Typical arrangement for fault loop impedance (Z_s) measurement in TN systems

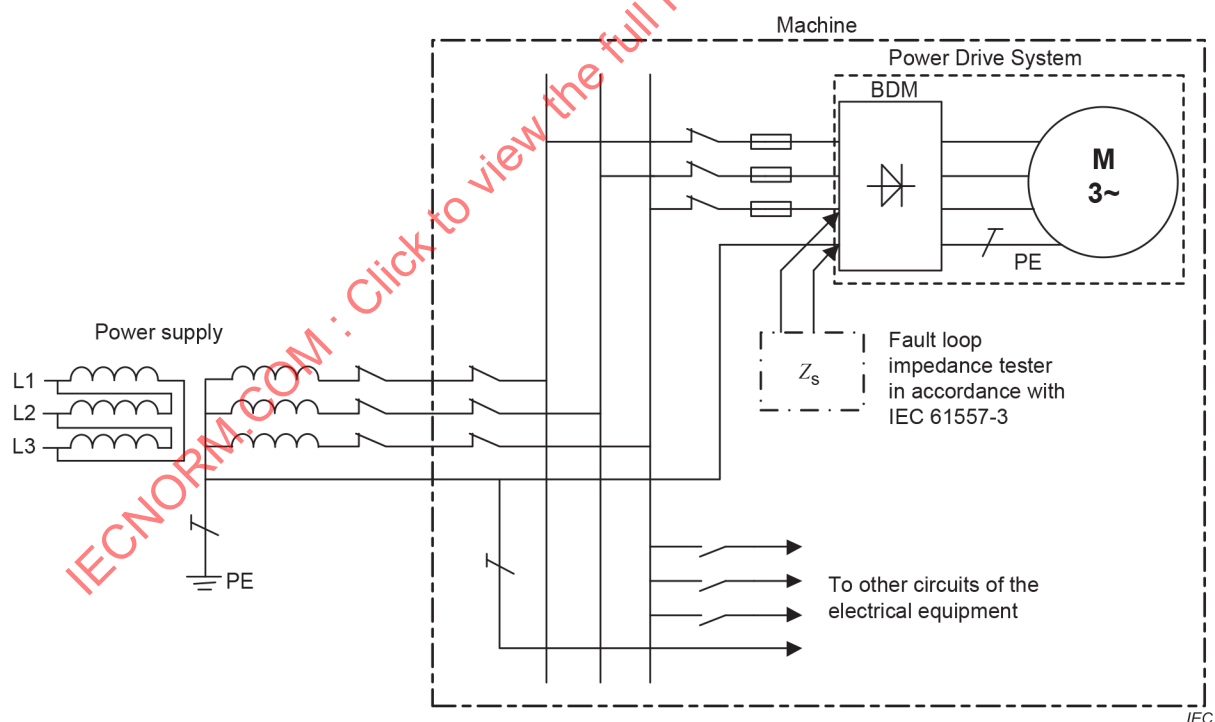


Figure A.2 – Typical arrangement for fault loop impedance (Z_s) measurement for power drive system circuits in TN systems

A.2 Fault protection for machines supplied from TT-systems

A.2.1 Connection to earth

All exposed-conductive-parts and all extraneous conductive parts shall be bonded to the protective bonding circuit.

Exception: see 8.2.5.

In addition to the requirements of 5.2, provision for additional earthing of machine elements and/or the PE conductor of the electrical equipment may be provided.

NOTE In a TT system, the neutral point or the mid-point of the power supply system is earthed, or where a neutral point or mid-point is not available or not accessible, a line conductor is earthed (derived from IEC 60364-4-41:2005, 411.5.1).

A.2.2 Fault protection for TT systems

A.2.2.1 General

Generally in TT systems, RCDs shall be used for fault protection. Alternatively, overcurrent protective devices may be used for fault protection provided a suitably low value of Z_s is permanently and reliably assured. Z_s is the impedance of the fault loop.

NOTE In some countries, the use of overcurrent protective devices is not permitted as the means of fault protection in TT systems.

Where automatic disconnection of supply is used as a measure for fault protection, the electrical equipment designer may either:

- use in the design calculations a value of earth electrode resistance or earth fault loop impedance measured in accordance with IEC 60364-6:2016 or declared by the intended user of the equipment (see Annex B); or
- for series-manufactured machines, specify a value of the earth electrode resistance or earth fault loop impedance suitable for the intended installations.

The electrical equipment designer shall state in the installation instructions the value of earth electrode resistance or earth fault loop impedance used for the design of the electrical equipment, specifying that this is the maximum value to which the machine can be connected.

Where a power drive system (PDS) is used, the disconnection time for fault protection shall meet the relevant requirements of this Annex A at the incoming supply terminals of the basic drive module (BDM) of the PDS. See Figure A.4.

A.2.2.2 Protection by residual current protective device (RCD)

Where a residual current protective device (RCD) is used for fault protection, the following conditions shall be fulfilled:

- disconnection time as required by Table A.2, and
- $R_A \times I_{\Delta n} \leq 50 \text{ V}$

where

R_A is the sum of the resistances of the earth electrode and the protective conductor for each exposed conductive-part;

$I_{\Delta n}$ is the rated residual operating current of the RCD.

Exception: a disconnection time not exceeding 1 s is permitted for distribution circuits and for circuits not covered by Table A.2.

NOTE 1 Fault protection is provided in this case also if the fault impedance is not negligible.

NOTE 2 Where discrimination between RCDs is necessary, information is given in 535.3 of IEC 60364-5-53:2019.

NOTE 3 The disconnection times in accordance with Table A.2 relate to prospective residual fault currents significantly higher than the rated residual operating current of the RCD (typically $5 I_{\Delta n}$).

NOTE 4 The definition of R_A is extracted from IEC 60364-4-41:2005. In this document, the term “earth electrode” in the definition of R_A is considered to mean the “earth-return path” as defined by IEC 60050-195:2021, 195-02-30.

A.2.2.3 Protection by overcurrent protective devices

Where an overcurrent protective device is used, the following condition shall be fulfilled:

$$Z_s \times I_a \leq U_0$$

where

Z_s is the impedance of the fault loop comprising:

- the source,
- the line conductor up to the point of the fault,
- the protective conductor of each exposed-conductive-part,
- the earthing conductor,
- the earth electrode of the installation and the earth electrode of the source;

I_a is the current causing the automatic operation of the disconnecting device within the time specified in Table A.2;

Exception: a disconnection time not exceeding 1 s is permitted for circuits not covered by Table A.2.

U_0 is the nominal AC or DC line-to-earth voltage.

The maximum disconnection times stated in Table A.2 shall be applied to circuits not exceeding 32 A. Maximum disconnection times shall not exceed 1 s for circuits 32 A or greater.

Table A.2 – Maximum disconnecting time for TT-systems

System	Maximum disconnecting time							
	s							
	$50 \text{ V} < U_0 \leq 120 \text{ V}$		$120 \text{ V} < U_0 \leq 230 \text{ V}$		$230 \text{ V} < U_0 \leq 400 \text{ V}$		$U_0 > 400 \text{ V}$	
	AC	DC	AC	DC	AC	DC	AC	DC
TT	0,3	NOTE	0,2	0,4	0,07	0,2	0,04	0,1
Where in TT systems the disconnection is achieved by an overcurrent protective device and all extraneous conductive parts will be connected to the protective bonding circuit, the maximum disconnection times specified in Table A.1 may be used. U_0 is the nominal AC or DC line-to-earth voltage. Disconnection can be required for reasons other than protection against electric shock.								

A.2.3 Verification of protection by automatic disconnection of supply using a residual current protective device (RCD)

Fault protection in a TT system by automatic disconnection of supply using an RCD shall be verified by the following:

- inspection of the rated residual current for tripping value, and the disconnecting time value of the RCD; and

- verification that the RCD has been tested in accordance with a relevant IEC standard; and
- inspection of the connections to the RCD and protective bonding circuit.

A.2.4 Measurement of the fault loop impedance (Z_s)

Where measurement of the fault loop impedance is performed, the measuring equipment should comply with IEC 61557-3. The information about the accuracy of the measuring results and the procedures to be followed given in the documentation of the measuring equipment shall be considered.

The measurement shall be performed with the electrical equipment connected to a supply of between 99 % and 101 % of the nominal frequency of the supply at the intended installation.

NOTE 1 Figure A.3 illustrates a typical arrangement for measuring the fault loop impedance on a machine.

If it is not practicable for the motor to be connected during the test, the two line conductors not used in the test may be opened, for example, by removing fuses.

NOTE 2 Figure A.4 illustrates a typical arrangement for measuring the fault loop impedance when a power drive system is used.

The measured value of the fault loop impedance shall be in accordance with A.2.2.3.

NOTE 3 Information on the verification of performance of an RCD and measurement of earth fault loop impedance can be found in IEC 60364-6:2016.

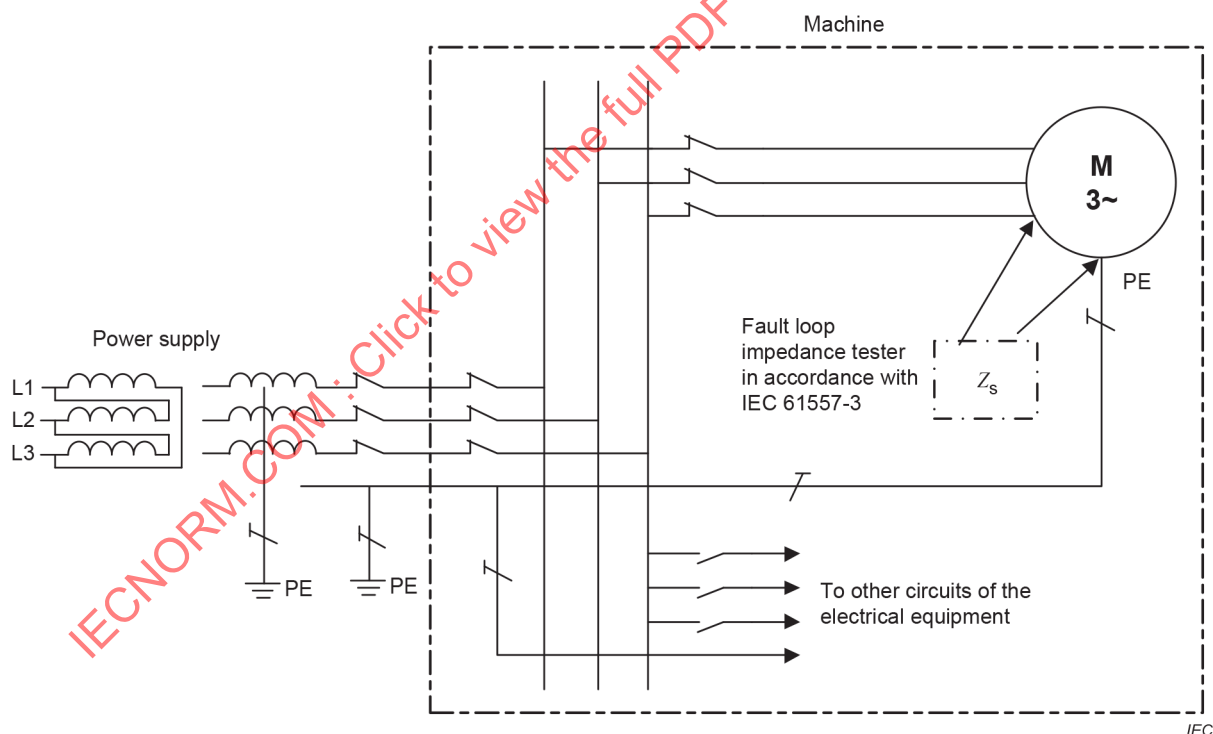


Figure A.3 – Typical arrangement for fault loop impedance (Z_s) measurement in TT systems

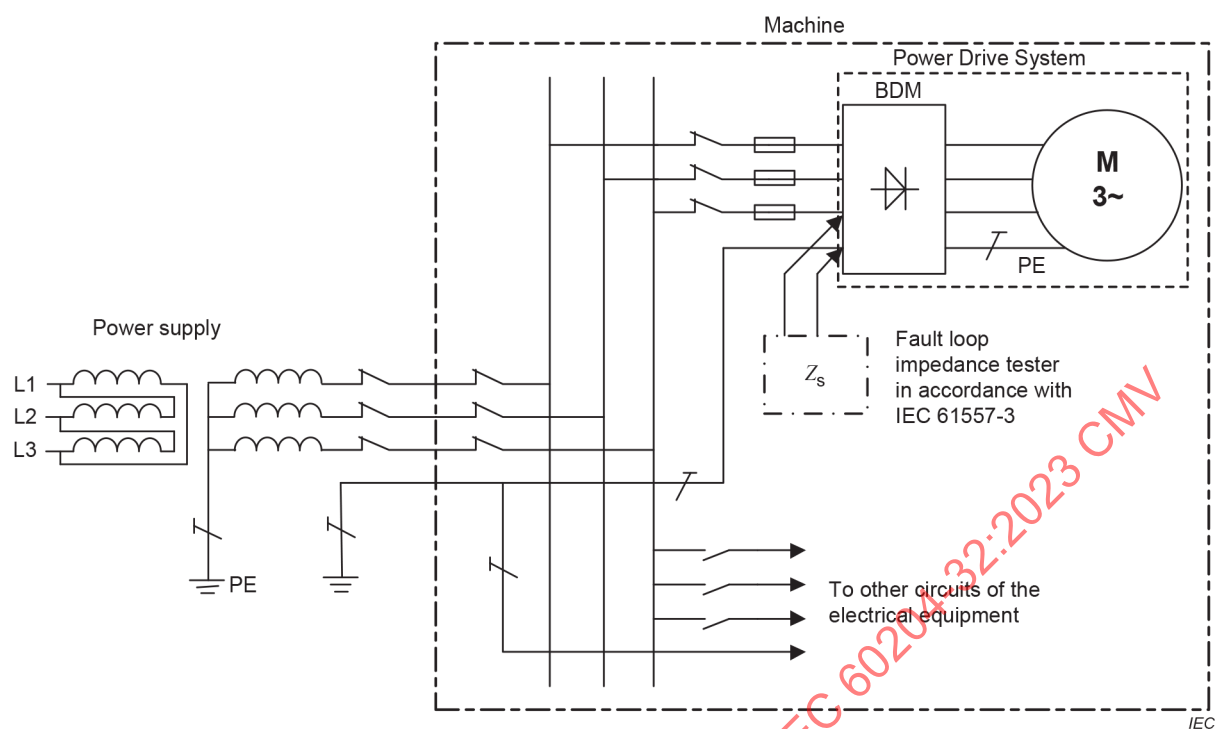


Figure A.4 – Typical arrangement for fault loop impedance (Z_s) measurement for Power Drive System circuits in TT systems

Annex B (informative)

Enquiry form for the electrical equipment of hoisting machines

~~It is recommended that the following information be provided by the intended user of the equipment. It can facilitate an agreement between the user and supplier on basic conditions and additional user specifications to enable proper design, application and utilization of the electrical equipment of the hoisting machine (see 4.1).~~

The use of this enquiry form can facilitate an exchange of information between the user and supplier on basic conditions and additional user requirements to enable suitable design, application and utilization of the electrical equipment of the hoisting machine (see 4.1) particularly when the conditions on site can deviate from those generally expected. **41**

Annex B can also serve as an internal checklist for serial manufactured hoisting machines.

Name of manufacturer/supplier			
Name of end user			
Tender/order number		Date	
Type of hoisting machine		Serial number	
1 Special conditions (see Clause 1)			
a) Is the hoisting machine to be used in the open air?	Yes		No
b) Will the hoisting machine handle or transport explosive, flammable or otherwise hazardous material?	Yes/No		If yes, specification
c) Is the hoisting machine for use in potentially explosive or flammable atmospheres?	Yes/No		If yes, specification
d) Is the hoisting machine for use in mines?	Yes		No
2 Electrical supplies and related conditions (see 4.3)			
a) Anticipated voltage fluctuations (if more than $\pm 10\%$)			
b) Anticipated frequency fluctuations (if more than $\pm 2\%$)	Continuous		Short time
c) Indicate possible future changes in electrical equipment that will require an increase in the electrical supply requirements			
d) Specify voltage interruptions in supply if longer than specified in Clause 4 where electrical equipment ~~shall~~ has to maintain operation under such conditions			
3 Physical environment and operating conditions (see 4.4)			
a) Electromagnetic environment (see 4.4.2)	Residential, commercial or light industrial environment		Industrial environment
Special EMC conditions or requirements			
b) Ambient temperature range			
c) Humidity range			
d) Altitude			
e) Special environmental conditions (e.g. corrosive atmospheres, dust, wet environments)			
f) Radiation			

g) Vibration, shock			
h) Special installation and operation requirements (e.g. flame-retardant cables and conductors)			
i) Transportation and storage (e.g. temperatures outside the range specified in 4.5)			
j) restrictions related to size, weight or point load			
4 Incoming electrical supplies			
Specify for each source of supply:			
a) Nominal voltage (V)	AC		DC
	If AC, number of phases		Frequency
Value of the supply source impedance (Ω) at the point of connection to the electrical equipment			
Prospective short-circuit current at the point of supply to the hoisting machine (kA RMS) (see also item 2)			
b) Type of power supply earthing (see IEC 60364-1:2005)	TN (system with one point directly earthed, with a protective conductor (PE) directly connected to that point); specify if the earthed point is the neutral point (centre of the star) or another point		TT (system with one point directly earthed but the protective conductor (PE) of the hoisting machine not connected to that earth point of the system)
	IT (system that is not directly earthed)		
In the case of IT systems, is insulation monitoring/fault location to be provided by the supplier of the electrical equipment?	Yes		No
c) Is the electrical equipment to be connected to a neutral (N) supply conductor? (see 5.1)	Yes		No
d) Crane-supply-switch			
Is disconnection of the neutral (N) conductor required?	Yes		No
Is a removable link for disconnecting the neutral (N) required?	Yes		No
Type of crane-supply-switch to be provided			
e) Cross sectional area and material of external protective (PE) conductor			
f) Is an RCD provided in the installation?	Yes/No		If yes, type and rated residual operating current
5 Protection against electric shock (see Clause 6)			
a) For which of the following classes of persons is access to the interior of enclosures required during normal operation of the equipment?	Electrically skilled persons		Electrically instructed persons

b) Are locks with removable keys to be provided for securing the doors or covers? (see 6.2.2)	Yes		No	
Type of locking device				
Basic lock unit (except key cylinder) to be supplied and installed by				
Key cylinder to be supplied and installed by				
6 Protection of equipment (see Clause 7)				
a) Will the user or the supplier provide the overcurrent protection of the supply conductors? (see 7.2.2)				
Type and rating of overcurrent protective devices				
b) Largest (kW) three-phase AC motor that may be started direct-on-line				
c) May the number of motor overload detection devices be reduced? (see 7.3)	Yes		No	
d) Is overvoltage protection to be provided?	Yes		If yes, specification	
7 Operation				
For cableless control systems, specify the time delay before automatic hoisting machine shutdown is initiated in the absence of a valid signal. (see 9.2.7.3)				
8 Operator interface and machine-mounted control devices (see Clause 10)				
Special colour preferences (e.g. to align with existing machinery)	Start		Stop	
	Other			
9 Controlgear				
Degree of protection of enclosures (see 11.3) or special conditions:				
10 Wiring practices (see Clause 13)				
Is there a specific method of identification to be used for the conductors? (see 13.2.1)	Yes		No	
Type				
11 Accessories and lighting (see Clause 15)				
a) Is a particular type of socket-outlet required?	Yes		No	
If yes, which type?				
b) Are the socket-outlets for maintenance to be provided with additional protection by the use of residual current protective devices (RCDs)?	Yes		No	
c) Where the hoisting machine is equipped with local lighting	Highest permissible voltage (V)		If lighting circuit voltage is not obtained directly from the power supply, state preferred voltage	
12 Marking, warnings and reference designations (see Clause 16)				
a) Functional identification (see 16.3)				
Specifications:				
b) Inscriptions/special markings	On electrical equipment?		In which language?	
c) Mark of certification	Yes		No	
If yes, which one?				

13	Technical documentation (see Clause 17)				
a)	Technical documentation (see 17.1)	On what media?		In which language?	
b)	Size, location and purpose of ducts, open cable trays or cable supports to be provided by the user (see 13.5)				
c)	Indicate if special limitations on the size or weight affect the transport of a particular hoisting machine or controlgear assemblies to the installation site	Maximum dimensions		Maximum weight	
14	Intended use of the hoisting machine (see 12.4 and Annex D)				
	What is the mean number of operating cycles per hour? (An operating cycle comprises all operations in all axes, beginning with the hoisting of a load and ending when the hoisting machine is ready for hoisting the next load.)				
	For what length of time is it expected that the hoisting machine will be operated at this rate without subsequent pause?				
	Length of subsequent pause?				

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Annex C (informative)

Current-carrying capacity and overcurrent protection of conductors and cables in the electrical equipment of machines

C.1 General

The purpose of this Annex C is to provide additional information on the selection of conductor sizes where the conditions given for Table 7 (see Clause 12) have to be modified (see notes to Table 7).

C.2 General operating conditions

C.2.1 Ambient air temperature

The current-carrying capacity for PVC-insulated conductors given in Table 7 is related to an ambient air temperature of +40 °C. For other ambient air temperatures, the correction factors are given in Table C.1.

The correction factors for rubber insulated cables are given by the manufacturer.

Table C.1 – Correction factors

Ambient air temperature °C	Correction factor
30	1,15
35	1,08
40	1,00
45	0,91
50	0,82
55	0,71
60	0,58
NOTE The correction factors are derived from IEC 60364-5-52. The maximum conductor temperature under normal conditions for PVC is 70 °C	

C.2.2 Methods of installation

In machines, the methods of conductor and cable installation between enclosures and individual items of the equipment shown in Figure C.1 are assumed to be typical (the letters used are in accordance with IEC 60364-5-52).

- Method B1: using conduits (see 3.1.12) and cable trunking systems (see 3.1.9) for holding and protecting conductors or single core cables
- Method B2: same as B1 but used for multi-core cables
- Method C: multi-core cables installed in free air, horizontal or vertical without gap between cables on walls
- Method E: multi-core cables in free air, horizontal or vertical laid on open cable trays (see 3.1.8)

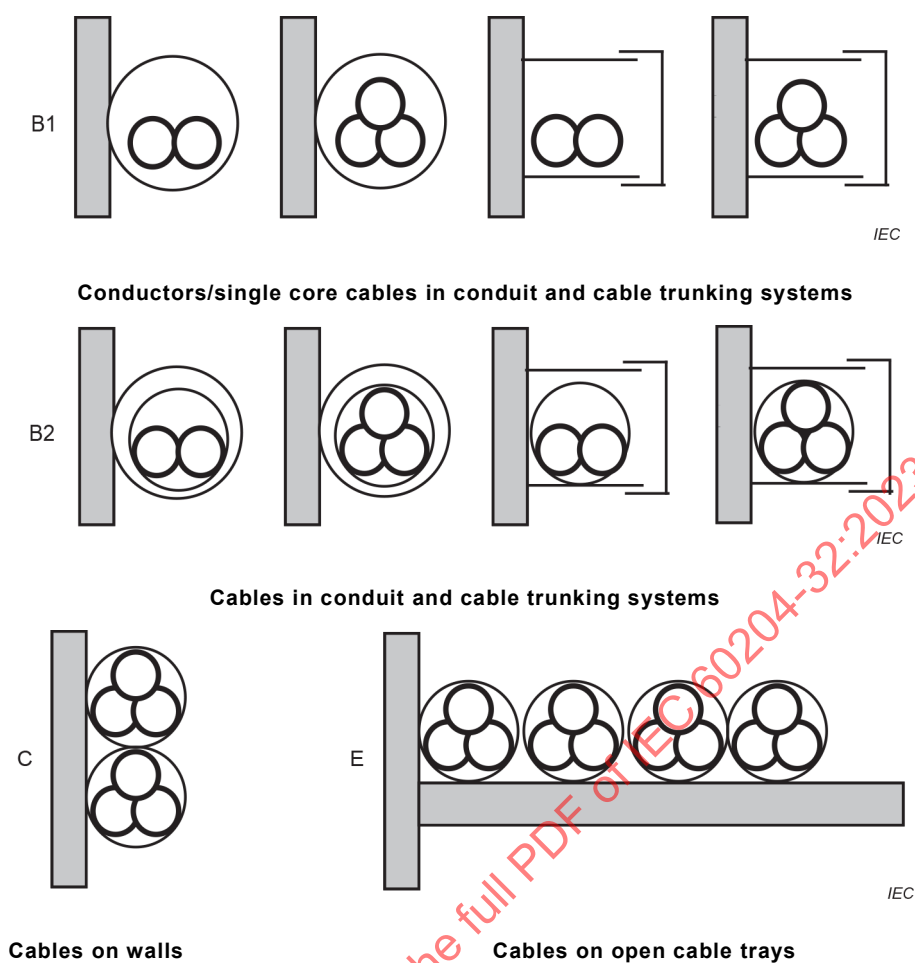


Figure C.1 – Methods of conductor and cable installation independent of number of conductors/cables

C.2.3 Grouping

Where more loaded conductors in cables or conductor pairs are installed, the values of I_z , given in Table 7 or by the manufacturer in accordance with Table C.2 or Table C.3, should be derated.

NOTE Circuits with $I_b < 30\%$ of I_z need not be derated.

Table C.2 – Derating factors ~~from~~ for I_z for grouping

Method of installation (see Figure C.1) ~~(see Note 3)~~	Derating factor			
	Number of loaded circuits/cables			
	2	4	6	9
B1 (circuits conductors or single core cables) and B2 (multicore cables)	0,80	0,65	0,57	0,50
C single layer with no gap between cables	0,85	0,75	0,72	0,70
E single layer on one perforated tray without gap between	0,88	0,77	0,73	0,72
E as before but with 2 to 3 trays, with a vertical spacing between each tray of 300 mm (see Note 4)	0,86	0,76	0,71	0,66
Control circuit pairs $\leq 0,5 \text{ mm}^2$ independent of methods of installation	0,76	0,57	0,48	0,40
NOTE 1 These factors are applicable to – cables, all equally loaded, the circuit itself symmetrically loaded; – groups of circuits of insulated conductors or cables having the same allowable maximum operating temperature. NOTE 2 The same factors are applied to – groups of two or three single-core cables; – multi-core cables. NOTE 3 Factors derived from IEC 60364-5-52. NOTE 4 A perforated cable tray is a tray where the holes occupy more than 30 % of the area of the base (derived from IEC 60364-5-52).				

Table C.3 – Derating factors ~~from~~ for I_z for multi-core cables up to 10 mm^2

Number of loaded conductors or pairs	Derating factor	
	Conductors $\geq 1 \text{ mm}^2$ (see Note 3)	Pairs ($0,25 \text{ mm}^2$ to $0,75 \text{ mm}^2$)
1	-	1,0
3	1,0	0,5
5	0,75	0,39
7	0,65	0,34
10	0,55	0,29
24	0,40	0,21
NOTE 1 Applicable to multi-core cables with equally loaded conductors/pairs. NOTE 2 For grouping of multi-core cables, see derating factors of Table C.2. NOTE 3 Factors derived from IEC 60364-5-52.		

C.2.4 Classification of conductors

Classification of conductors is given in Table C.4.

Table C.4 – Classification of conductors

Class	Description	Use/application
1	Solid copper or aluminium conductors	Fixed installations
2	Stranded copper or aluminium conductors	
5	Flexible stranded copper conductors	Machine installations with presence of vibration; connection to moving parts For frequent movements
6	Flexible stranded copper conductors that are more flexible than class 5	
NOTE Derived from IEC 60228.		

C.3 Co-ordination between conductors and protective devices providing overload protection

Figure C.2 illustrates the relationship between the parameters of conductors and the parameters of protective devices providing overload protection.

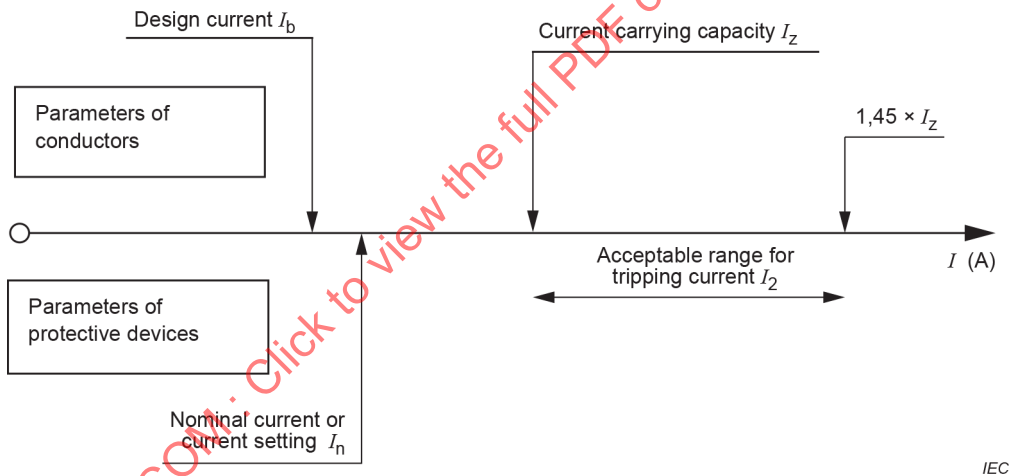


Figure C.2 – Parameters of conductors and protective devices

Correct protection of a cable requires that the operating characteristics of a protective device (e.g. overcurrent protective device, motor overload protective device) protecting the cable against overload satisfy the two following conditions:

$$I_b \leq I_n \leq I_z \tag{C.1}$$

$$I_2 \leq 1,45 \times I_z \tag{C.2}$$

where

I_b is the current for which the circuit is designed;

I_z is the effective current-carrying capacity, in amperes, of the cable for continuous service in accordance with Table 7 for the particular installation conditions:

- temperature, for derating of I_z see Table C.1;
- grouping, for derating of I_z see Table C.2;
- multi-core cables, for derating of I_z see Table C.3.

I_n is the nominal current of the protective device;

NOTE 1 For adjustable protective devices, the nominal current I_n is the current setting selected.

I_2 is the minimum current ensuring effective operation of the protective device within a specified time (e.g. 1 h for protective devices up to 63 A).

The current I_2 ensuring effective operation of the protective device is given in the product standard or may be provided by the manufacturer.

NOTE 2 For motor circuit conductors, overload protection for conductor(s) can be provided by the overload protection for the motor(s) whereas the short-circuit protection is provided by short-circuit protective devices.

Where a device that provides both overload and short-circuit protection is used in accordance with Clause C.3 for conductor overload protection, it does not ensure complete protection in all cases (e.g. overload with currents less than I_2) nor will it necessarily result in an economical solution. Therefore, such a device can be unsuitable where overloads with currents less than I_2 are likely to occur.

C.4 Overcurrent protection of conductors

All conductors are required to be protected against overcurrent (see 7.2) by protective devices inserted in all live conductors so that any short-circuit current flowing in the cable is interrupted before the conductor has reached the maximum allowable temperature. Maximum allowable conductor temperatures under normal and short-circuit conditions are given in Table C.5.

NOTE For neutral conductors, see 7.2.3, second paragraph.

Table C.5 – Maximum allowable conductor temperatures under normal and short-circuit conditions

Type of insulation	Maximum temperature under normal conditions °C	Ultimate short-time conductor temperature under short circuit conditions ^a °C
Polyvinyl chloride (PVC)	70	160
Rubber	60	200
Cross-linked polyethylene (XLPE)	90	250
Ethylene propylene compound (EPR)	90	250
Silicone rubber (SiR)	180	350
NOTE For ultimate short-time conductor temperatures greater than 200 °C, neither tinned nor bare copper conductors are suitable. Silver-plated or nickel-plated copper conductors are suitable for use above 200 °C.		
^a These values are based on the assumption of adiabatic behaviour for a period of not more than 5 s.		

In practice, the requirements of 7.2 are fulfilled when the protective device at a current I causes the interruption of the circuit within a time that in no case exceeds the time t where $t < 5$ s.

The value of the time t in seconds ~~shall~~ can be calculated using the following formula:

$$t = (k \times S/I)^2$$

where

S is the cross-sectional area in square millimetres;

I is the effective short-circuit current in amperes expressed for AC as the RMS value;

k is the factor shown for copper conductors when insulated with the following material:

PVC	115
Rubber	141
SiR	132
XLPE	143
EPR	143

The use of fuses with characteristics gG or gM (see IEC 60269-1:2009) and circuit-breakers with characteristics B and C in accordance with the IEC 60898 series, ensures that the temperature limits in Table C.5 will not be exceeded, provided that the nominal current I_n is chosen in accordance with Table 7 where $I_n \leq I_z$.

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Annex D (informative)

Conductor selection for intermittent duty

D.1 General

For specific applications where the correct conductor dimensioning can depend on the relationship between the period of the duty cycle and the thermal time constant of the conductor, the conductor manufacturer should be consulted. Conductors for intermittent duty should be selected in accordance with the conductor manufacturer's instructions. If such information is not available, the criteria presented in this Annex D can be used.

The method presented in Clause D.2 assumes that the cycle consists of an on-time and off-time. During on-time the current is at a constant level and during off-time there is no current. The cycle time (on-time plus off-time) is assumed to be 10 min.

If the cycle time is other than 10 min, it can be calculated in accordance with Clause D.3.

In some applications, the current during the on-time varies and also the cycle time can vary. The thermal equivalent current representing these variations can be calculated by applying Clause D.4.

D.2 Intermittent duty with 10-min cycle

Conductor selection for intermittent use should be made according to the conductor manufacturer's instructions. If such information is not available, the criteria presented in Clause D.2 can be used.

Table D.1 defines the correction factor f_{ED} for conductor current-carrying capacity in intermittent duty when the duration of the operating cycle is 10 min.

The correction factor depends on the duration of the load cycle compared to the thermal time constant of the conductor. Intermittent use consists of

- on-time (T_a), and
- off-time (T_i).

Table D.1 – Correction factor for 10 min cycle

Cross-section mm ²	Correction factor, f_{ED} , for a 10-min cycle $Ta/(Ta + Ti)$			
	0,6	0,4	0,25	0,15
1,5	1,044	1,120	1,265	1,505
2,5	1,058	1,150	1,315	1,580
4	1,075	1,183	1,369	1,660
6	1,092	1,215	1,421	1,737
10	1,116	1,260	1,493	1,842
16	1,139	1,303	1,561	1,942
25	1,161	1,344	1,626	2,037
35	1,177	1,373	1,673	2,105
50	1,193	1,403	1,719	2,173
70	1,207	1,429	1,760	2,231
95	1,219	1,450	1,793	2,280
120	1,227	1,464	1,816	2,314
150	1,234	1,477	1,836	2,343
185	1,240	1,488	1,854	2,369
240	1,247	1,501	1,874	2,397
300	1,252	1,510	1,888	2,419

D.3 Intermittent duty with any cycle time

If the duration of the operating cycle is shorter than 10 min, higher correction factors than in Table D.1 can be used, and if the duration of the operating cycle is longer, then lower correction factors should be applied. Correction factors to any particular operating cycle can be calculated using the following formula:

$$f_{ED} = \sqrt{\frac{1 - e^{-\left(\frac{Ta + Ti}{T}\right)}}{1 - e^{-\left(\frac{Ta}{T}\right)}}$$

Where T is the thermal time constant of the conductor, which can be taken from Table D.2.

Table D.2 – Thermal time constant of conductors

Cross-sectional area (mm ²)	1,5	2,5	4	6	10	16	25	35	50	70	95	120	150	185	240	300
T (min)	2,7	3,1	3,6	4,2	5,2	6,4	7,9	9,4	11,3	13,6	16,1	18,4	21,0	23,7	27,7	31,8

D.4 Calculation of thermal equivalent current

For intermittent periodic duty applications (e.g. where frequent motor starting occurs), it is recommended that conductors suitable for the thermal equivalent current, I_q , be selected. I_q is also used for coordination with overcurrent protection. I_q may be calculated as follows:

$$I_q = \sqrt{\frac{\sum_{k=1}^N I_k^2 \times t_k}{t_s}}$$

where

I_q is the thermal equivalent current in amperes;

t_s is the duty cycle time in seconds;

I_k, t_k are the current and time of the segments of the operating cycle.

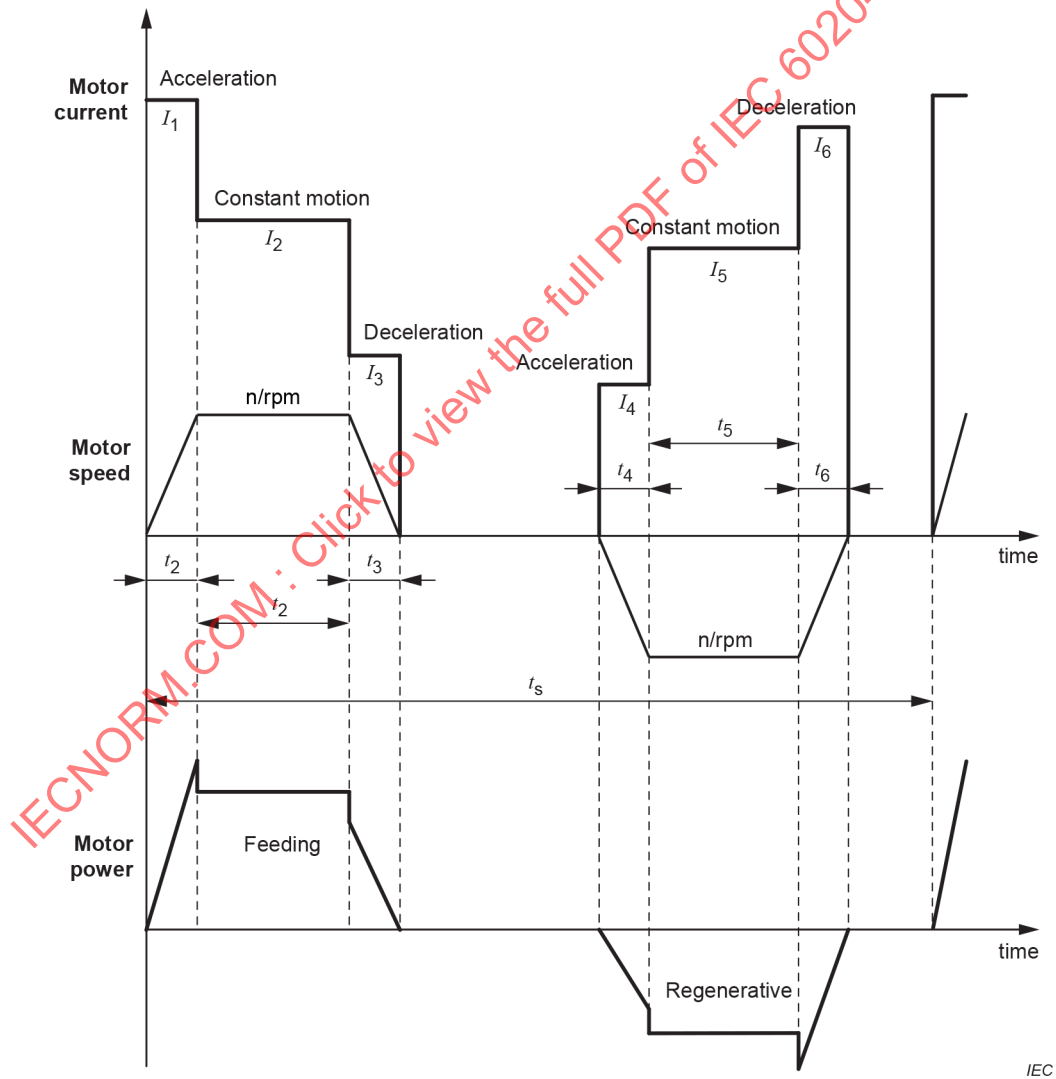


Figure D.1 – An example of current and time of the segments of the operating cycle of a variable speed AC hoist drive

For example, the thermal equivalent current for the operating cycle illustrated in Figure D.1 can be calculated using the following formula:

$$I_q = \sqrt{\frac{I_1^2 \times t_1 + I_2^2 \times t_2 + I_3^2 \times t_3 + I_4^2 \times t_4 + I_5^2 \times t_5 + I_6^2 \times t_6}{t_s}}$$

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Annex E (informative)

Explanation of emergency operation functions

E.1 Emergency operations

Emergency operation includes separately or in combination:

- emergency stop (E.2);
- emergency start (E.3);
- emergency switching-off (E.4);
- emergency switching-on (E.5).

NOTE These concepts are included here to give the reader an understanding of these terms, even though in this document only two of them are used.

E.2 Emergency stop

This is an emergency operation intended to stop a process or a movement that has become hazardous.

E.3 Emergency start

This is an emergency operation intended to start a process or a movement to remove or to avoid a hazardous situation.

E.4 Emergency switching-off

This is an emergency operation intended 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.

E.5 Emergency switching-on

This is an emergency operation intended to switch on the supply of electrical energy to a part of an installation that is intended to be used for emergency situations.

Annex F (informative)

Comparison of typical conductor cross-sectional areas

Table F.1 provides a comparison of the conductor cross-sectional areas of the American Wire Gauge (AWG) with square millimetres, square inches, and circular mils.

Table F.1 – Comparison of conductor sizes

Wire size mm ²	Gauge No. (AWG)	Cross-sectional area		DC resistance of copper at 20 °C Ω/km	Circular mils
		mm ²	in ²		
0,2		0,196	0,000 304	91,62	387
	24	0,205	0,000 317	87,60	404
0,3		0,283	0,000 438	63,46	558
	22	0,324	0,000 504	55,44	640
0,5		0,500	0,000 775	36,70	987
	20	0,519	0,000 802	34,45	1 020
0,75		0,750	0,001 162	24,80	1 480
	18	0,823	0,001 272	20,95	1 620
1,0		1,000	0,001 550	18,20	1 973
	16	1,31	0,002 026	13,19	2 580
1,5		1,500	0,002 325	12,20	2 960
	14	2,08	0,003 228	8,442	4 110
2,5		2,500	0,003 875	7,56	4 934
	12	3,31	0,005 129	5,315	6 530
4		4,000	0,006 200	4,700	7 894
	10	5,26	0,008 152	3,335	10 380
6		6,000	0,009 300	3,110	11 841
	8	8,37	0,012 967	2,093	16 510
10		10,000	~~0,015 50~~ 0,015 50	1,840	19 735
	6	13,3	0,020 610	1,320	26 240
16		16,000	0,024 800	1,160	31 576
	4	21,1	0,032 780	0,829 5	41 740
25		25,000	0,038 800	0,734 0	49 338
	2	33,6	0,052 100	0,521 1	66 360
35		35,000	0,054 200	~~0,529 0~~ 0,525 7	69 073
	1	42,4	0,065 700	0,413 9	83 690
50		~~47,000~~ 50,000	~~0,072 800~~ 0,077 5	~~0,391 0~~ 0,368 0	~~92 756~~ 99 072
	0	47	0,072 87	0,391 5	93 128

The resistance for temperatures other than 20 °C can be found using the formula:

$$R = R_1 [1 + 0,003\,93 (t - 20)]$$

where

R_1 is the resistance at 20 °C;

R is the resistance at a temperature t °C

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Annex G (informative)

Measures to reduce the effects of electromagnetic influences 42

G.1 General

This **Annex G** provides recommendations to improve electromagnetic immunity and reduce emission of electromagnetic disturbances.

For EMC purposes, electrical equipment for machinery is deemed to be either apparatus or fixed installations. Where electrical safety and electromagnetic compatibility result in different requirements, electrical safety always has the higher priority.

Electromagnetic interference (EMI) can disturb or damage process monitoring, control and automation systems. Currents due to lightning, switching operations, short-circuits and other electromagnetic phenomena can cause overvoltages and electromagnetic interference.

These effects can occur for example:

- where large conductive loops exist,
- where different electrical wiring systems are installed in common routes, e.g. power supply, communication, control or signal cables.

Cables carrying large currents with a high rate of change of current (di/dt) can induce overvoltages in other cables, which can influence or damage the connected electrical equipment.

In some applications, immunity and/or emission requirements of the electrical equipment can be met when the following conditions are fulfilled:

- the incorporated devices and components comply with the EMC requirements for the intended EMC environment specified in the relevant product standard (or generic standard where no product standard exists); and
- the electrical installation and wiring are consistent with the instructions provided by the supplier of the devices and components with regard to mutual influences (cabling, screening, earthing etc.) or with informative **Annex G** if such instructions are not available from the supplier.

G.2 Mitigation of electromagnetic interference (EMI)

G.2.1 General

Consideration should be given, in the design of the electrical equipment to the measures described in G.2.2 for reducing the electromagnetic influences on electrical equipment.

Only electrical equipment which meets the requirements of the appropriate EMC standards, or the EMC requirements of the relevant product standard, should be used.

G.2.2 Measures to reduce EMI

The following measures reduce electromagnetic interference.

- a) The installation of surge protection devices and/or filters for equipment sensitive to electromagnetic influences is recommended to improve electromagnetic compatibility with regard to conducted electromagnetic phenomena.
- b) Conductive sheaths (e.g. armouring, screens) of cables should be bonded to the protective bonding circuit.
- c) Inductive loops should be avoided by selection of common routes for power, signal and data circuits wiring while maintaining circuit separation in accordance with Clause G.3.
- d) Power cables should be kept separate from signal or data cables.
- e) Where it is necessary for power and signal or data cables to cross each other, they should be crossed at right-angles.
- f) Cables with concentric conductors are used to reduce currents induced into the protective conductor.
- g) Symmetrical multicore cables (e.g. screened cables containing separate protective conductors) are used for the electrical connections between motors and converters.
- h) Signal and data cables are used according to the EMC requirements of the manufacturer's instructions.
- i) Where screened signal or data cables are used, care should be taken to reduce current flowing through the screens of signal cables, or data cables, which are earthed. It can be necessary to install a by-pass conductor; see Figure G.1.

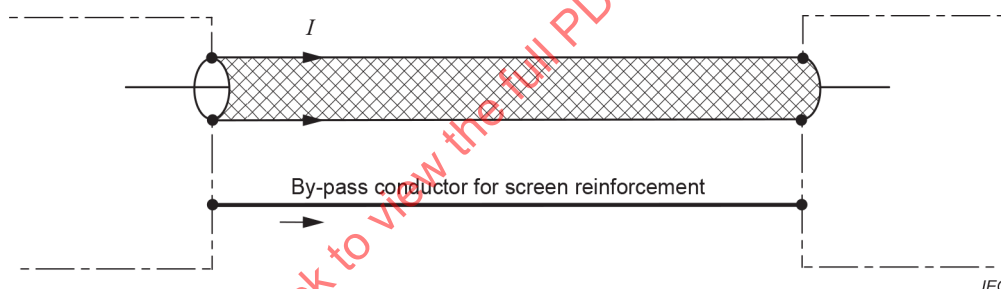


Figure G.1 – By-pass conductor for screen reinforcement

NOTE A good equipotential bonding of the components of the machine reduces the need for by-pass conductors.

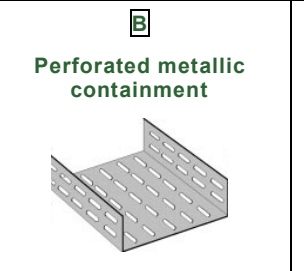
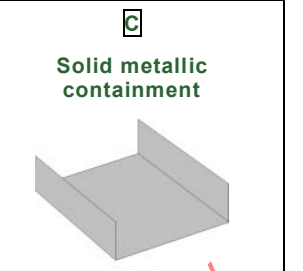
- j) Equipotential bonding connections should have an impedance as low as practicable by being as short as practicable and where applicable braided to conduct higher frequencies.
- k) If electronic equipment requires a reference voltage at about earth potential in order to function correctly, this reference voltage is provided by the functional earthing conductor. For equipment operating at high frequencies, the connections shall be kept as short as practicable.

G.3 Separation and segregation of cables

Power cables and data cables which share the same route should be installed according to the requirements of this Annex G.

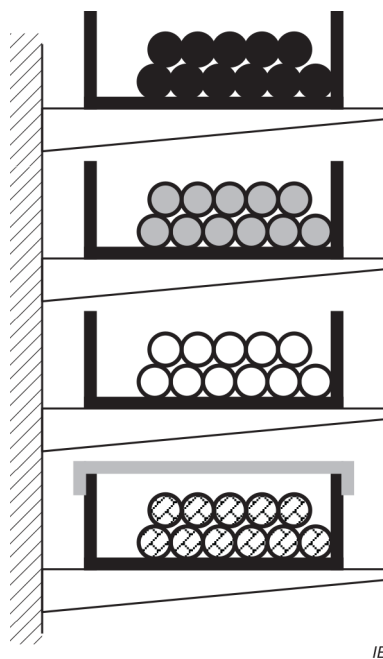
Where no other information is available, then the cable separation distance between the power and data cables should be in accordance with Table G.1 and Figure G.2.

Table G.1 – Minimum separation distances using metallic containment as illustrated in Figure G.2

Separation without metallic containment	A Mesh metallic containment	B Perforated metallic containment	C Solid metallic containment
			
≥ 200 mm	≥ 150 mm	≥ 100 mm	0 mm
A Screening performance (DC-100 MHz) equivalent to welded mesh steel basket of mesh size 50 mm × 100 mm (excluding ladders). This screening performance is also achieved with steel tray even if the wall thickness is less than 1 mm and/or the evenly distributed perforated area is greater than 20 %. B Screening performance (DC-100 MHz) equivalent to steel tray of at least 1 mm wall thickness and no more than 20 % evenly distributed perforated area. This screening performance is also achieved with screened power cables. No part of the cable within the metallic containment should be less than 10 mm below the top of the metallic containment. C Screening performance (DC-100 MHz) equivalent to a steel conduit of at least 1 mm wall thickness. Separation specified is in addition to that provided by any divider/screen.			

The minimum separation requirement specified in Table G.1 applies to the horizontal or vertical separation between adjacent cable trays or cable trunking systems. Where data cables and power supply cables are required to cross and required minimum separation cannot be maintained then the angle of their crossing should be maintained at 90 degrees on either side of the crossing for a distance no less than the applicable minimum separation requirement.

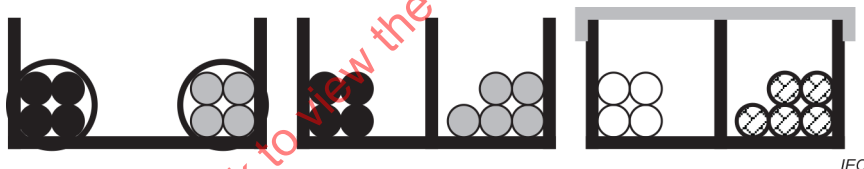
Figure G.2 and Figure G.3 show examples of separation and segregation.



For distances see Table G.1

 power supply cabling	 auxiliary circuits
 data cabling	 sensitive circuits (e.g. measurement)

Figure G.2 – Examples of vertical separation and segregation



For distances see Table G.1

Figure G.3 – Examples of horizontal separation and segregation

Usable space within the cable tray or cable trunking system should allow for an agreed quantity of additional cables to be installed (see Annex B). The cable bundle height should be lower than the side-walls of the cable tray or cable trunking system, as shown in Figure G.4. The overlapping lid of cable trunking systems improves the electromagnetic compatibility performance.

For a U-shape cable tray, the magnetic field decreases near the two corners. For this reason, deep side-walls are preferred.

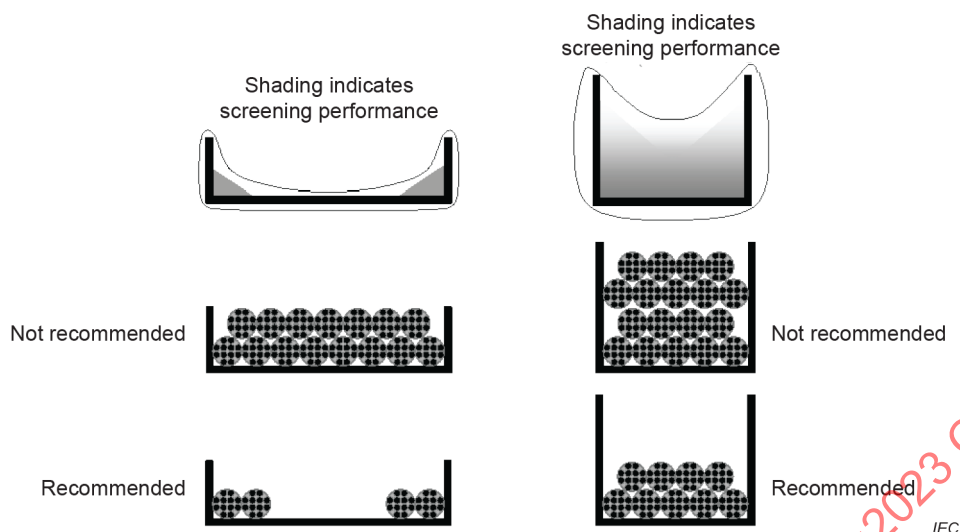


Figure G.4 – Cable arrangements in metal cable trays

Metal cable trays or cable trunking systems which are intended to provide electromagnetic compatibility shall always be connected to the local equipotential bonding system at both ends. For long distances, for example greater than 50 m, additional connections to the equipotential bonding system are recommended. All connections to the equipotential bonding system should have low impedance.

Where metal cable trays or cable trunking systems are constructed from several elements, care should be taken to ensure continuity by effective bonding between adjacent elements.

The shape of the metallic section should achieve continuity of shielding throughout its length. All interconnections should have low impedance; see Figure G.5.

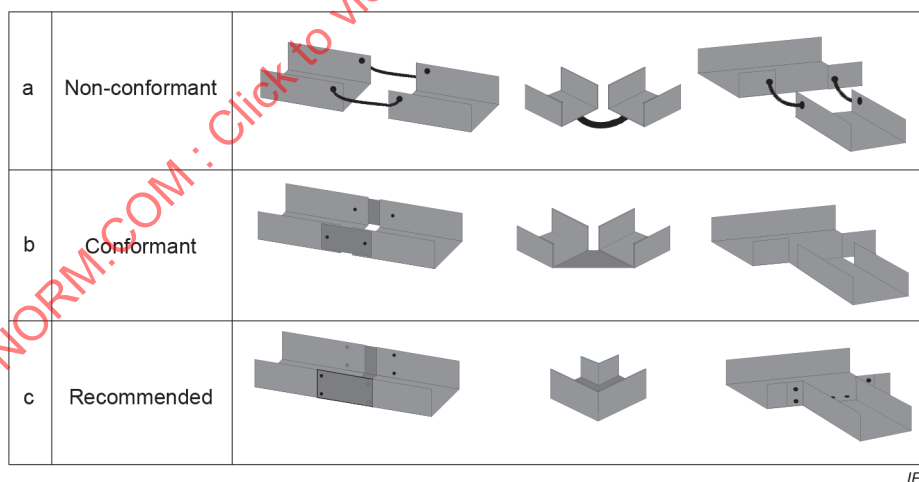


Figure G.5 – Connections between metal cable trays or cable trunking systems

Where metallic covers for metallic cable trunking systems are used, a cover over the full length is preferred. If that is not possible, the covers should be connected to the cable tray at least at both ends by short connections less than 10 cm, e.g. braided or mesh straps.

Figure G.6 shows a metal cable tray crossing a wall at which a fire barrier is to be installed. Where metal cable trays are required to be interrupted to pass through building structures, a low impedance interconnection should be provided between the two metallic sections. Regulations with respect to fire barriers take precedence over EMC considerations.

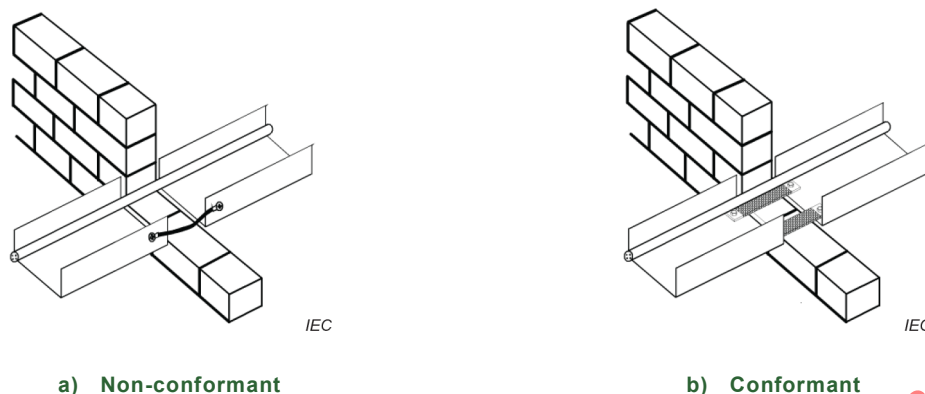


Figure G.6 – Interruption of metal cable trays at fire barriers

G.4 Power supply of a machine by parallel sources

Where a machine is supplied with power by parallel sources, see IEC 60364-1:2005.

G.5 Supply impedance where a Power Drive System (PDS) is used

Connection of a PDS to too high a supply source impedance can lead to conducted emission problems.

G.6 Emission levels for electrical equipment for PDS

Limits for the interference voltage for the environments and categories are listed in Table G.2.

Table G.2 – Limits for the interference voltage for the environments / categories

Location	Frequency range	Residential environment		Residential or Industrial environments (Residential when fixed installation by expert staff and warning notice)		Industrial environment with warning notice			
		PDS of category C1		PDS of category C2		PDS of category C3			
						PDS $I \leq 100$ A		PDS $I > 100$ A	
	MHz	Quasi peak dB μ V/m	Average dB μ V/m	Quasi peak dB μ V/m	Average dB μ V/m	Quasi peak dB μ V/m	Average dB μ V/m	Quasi peak dB μ V/m	Average dB μ V/m
AC power port	0,15	66	56	79	66	100	90	130	120
	0,50	56	46	79	66	100	90	130	120
	0,50	56	46	73	60	86	76	125	115
	5,00	56	46	73	60	86	76	125	115
	5,00	60	50	73	60	90	80	115	105
	30,00	60	50	73	60	70	60	115	105
Enclosure	30,00	30		40		50		50	
	230,00	30		40		50		50	
	230,00	37		47		60		60	
	1 000,00	37		47		60		60	

Table G.3 – Limits for propagated electromagnetic disturbance

	Frequency range	Magnetic field strength component expressed in electric field units – quasi peak
	MHz	Quasi peak dB μ V/m
Radiation	$0,15 \leq f \leq 0,49$	75
	$0,49 < f \leq 3,95$	65
	$3,95 < f \leq 20$	50
	$20 < f \leq 30$	40
	$30 \leq f \leq 230$	30
	$230 < f \leq 1\,000$	37

In case of interference, the radiation shall be measured at a distance of 10 m from the boundary of the installation if interference occurs outside in the first environment, or at a distance of 30 m from the boundary of the installation if interference occurs outside in the second environment.

For PDSs of category C4, the following procedure shall be used.

Due to technical reasons, there are some applications where it is not possible for the PDS to comply with the limits of Table G.3. These applications are for large ratings or to meet specific technical requirements:

- voltage above 1 000 V;
- current above 400 A;
- networks isolated from earth, or connected to earth through a high impedance (IT system according to 312.2.3 of IEC 60364-1:2005);
- where required dynamic performances will be limited as a result of filtering.

In these applications of category C4 equipment, the user and the manufacturer shall agree on an EMC plan to meet the EMC requirements of the intended application.

G.7 Conducted disturbances

Limits for conducted disturbances are given in Table G.4.

Table G.4 – Limits for conducted disturbances

	Frequency range	Residential environment		Industrial environments (Residential when fixed installation by expert staff and warning notice)		Industrial environments (not allowed in Residential environment)	
		PDS of category C1		PDS of category C2		PDS of category C3	
	MHz	Quasi peak dB μ V/m	Average dB μ V/m	Quasi peak dB μ V/m	Average dB μ V/m	Quasi peak dB μ V/m	Average dB μ V/m
Conduction	0,15	66	56	79	66	100	90
	0,50	56	46	79	66	100	90
	0,50	56	46	73	60	86	76
	5,00	56	46	73	60	86	76
	5,00	60	50	73	60	90	80
	30,00	60	50	73	60	70	60

G.8 Immunity requirements – Performance criteria

A functional description and a definition of equipment under test (EUT) specific performance criteria, during or as a consequence of immunity testing, shall be provided by the manufacturer and noted in the test report. They shall be consistent with one of the following general criteria for each test as specified:

- a) Performance criterion A: The EUT shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the EUT is used as intended. If the performance level is not specified by the manufacturer, this may be derived from the product description and documentation and what the user may reasonably expect from the equipment if used as intended.
- b) Performance criterion B: The EUT shall continue to operate as intended after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the EUT is used as intended. The performance level may be replaced by a permissible loss of performance. However, during the test degradation of performance is allowed but no change of actual operating state or stored data is allowed. If the minimum performance level or the permissible performance loss is not specified by the manufacturer, either of these may be derived from the product description and documentation and what the user may reasonably expect from the equipment if used as intended.
- c) Performance criterion C: Temporary loss of function is allowed during the test, provided the function is self-recoverable or can be restored by the operation of the controls. If, as a result of the application of the tests defined in this document, the EUT becomes dangerous or unsafe, it shall be deemed to have failed the test.

NOTE For further information see IEC 61000-6-2.

For immunity requirements and performance criteria, see Table G.5.

Table G.5 – Immunity requirements – performance criteria

Environmental phenomena	Test specifications	Performance criterion	See basic standards
Radio frequency magnetic field. Amplitude modulated	80 MHz to 1 000 MHz 10 V/m 80 % AM (1 kHz)	A	IEC 61000-4-3
Electrostatic discharge. Contact discharge	±4 kV	B	IEC 61000-4-2
Electrostatic discharge. Air discharge	±8 kV	B	IEC 61000-4-2

Annex H (informative)

Documentation and information 43

A list of available standards applicable to documentation and information is provided in Table H.1.

Brief definitions of a set of internationally standardized document kinds are given in the publicly available database IEC 61355 DB (<http://std.iec.ch/iec61355>).

Table H.1 – Documentation and information that can be applicable

Type of information for the electrical equipment	Reference standard
Structuring principles	IEC 81346-1, Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 1: Basic rules
Structuring of documents	IEC 62023, Structuring of technical information and documentation ^a
Parts list	IEC 62027, Preparation of object lists, including parts lists
List of documents	IEC 62027, Preparation of object lists, including parts lists
Specification of the properties of the electrical equipment	IEC PAS 62569-1, Generic specification of information on products by properties – Part 1: Principles and methods
Instructions for handling, transportation and storage	IEC/IEEE 82079-1, Preparation of information for use (instructions for use) of products – Structuring, content and presentation – Part 1: Principles and general requirements
Instructions for installation, erection, assembling on site, dismantling, etc.	IEC/IEEE 82079-1, Preparation of information for use (instructions for use) of products – Structuring, content and presentation – Part 1: Principles and general requirements
Instructions for use	IEC/IEEE 82079-1, Preparation of information for use (instructions for use) of products – Structuring, content and presentation – Part 1: Principles and general requirements
Instructions for service and maintenance	IEC/IEEE 82079-1, Preparation of information for use (instructions for use) of products – Structuring, content and presentation – Part 1: Principles and general requirements
Reference designations	IEC 81346-1, Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 1: Basic rules and IEC 81346-2, Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 2: Classification of objects and codes for classes
Terminal designations	IEC 61666, Industrial systems, installations and equipment and industrial products – Identification of terminals within a system
Designations of cables and cores	IEC 62491, Industrial systems, installations and equipment and industrial products – Labelling of cables and cores
Circuit diagrams	IEC 61082-1, Preparation of documents used in electrotechnology – Part 1: Rules
Layout of equipment and overall dimensions	IEC 61082-1, Preparation of documents used in electrotechnology – Part 1: Rules
Interconnection diagram, terminal list, cable list, cable tray layout	IEC 61082-1, Preparation of documents used in electrotechnology – Part 1: Rules
Spare parts list for a specified period	IEC 62027, Preparation of object lists, including parts lists
List of parameters (e.g. of converters)	(No standard exists)

Type of information for the electrical equipment	Reference standard
List of tools	IEC/IEEE 82079-1, Preparation of information for use (instructions for use) of products – Structuring, content and presentation – Part 1: Principles and general requirements
Identification systems	IEC 62507-1, Identification systems enabling unambiguous information interchange – Requirements – Part 1: Principles and methods
^a For simple equipment, IEC 62023 allows all information to be contained within a single document.	

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~~IEC 60050-411, International Electrotechnical Vocabulary (IEV) – Chapter 411: Rotating machines~~

IEC 60050-441:1984 *International Electrotechnical Vocabulary (IEV) – Chapter 441: Switchgear, controlgear and fuses*
IEC 60050-441:1984/AMD1:2000

~~IEC 60050-442, International Electrotechnical Vocabulary (IEV) – Part 442: Electrical accessories~~

IEC 60050-826:2022, *International Electrotechnical Vocabulary (IEV) – Part 826: Electrical installations*

IEC 60085, *Electrical insulation – Thermal evaluation and designation*

IEC 60204-11, *Safety of machinery – Electrical equipment of machines – Part 11: Requirements for ~~HV~~ equipment for voltages above 1 000 V AC or 1 500 V DC and not exceeding 36 kV*

~~IEC 60204-31, Safety of machinery – Electrical equipment of machines – Part 31: Particular safety and EMC requirements for sewing machines, units, and systems~~

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IEC 60898 (all parts), Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations

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~~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~~

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This index lists, in alphabetical order, the terms defined in Clause 3 and indicates where they are used in the text of this standard.

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List of comments

- 1 Hoisting machines are controlled more and more by programmable electronic equipment, so the scope has to be adjusted.
- 2 Not only one machine is working, also groups of machines have to be considered.
- 3 An additional annex for hoisting machines will be included in IEC 60204-11.
- 4 As much as possible the definitions are aligned with IEC vocabulary.
- 5 New subclause is added to have all abbreviated terms listed in one place in the standard.
- 6 This is a basic requirement not only for information.
- 7 Hoisting machines mostly having variable speed drives, so the standard therefore should be followed.
- 8 New power systems (for example DC bus systems) may work on wider ranges than direct driven AC systems, that is why the limits are deleted in this standard.
- 9 There are new subclauses in Annex G describing EMC, and also proposed levels beginning Annex G.6.
- 10 More examples are given to provide help to the designer of a hoisting machine.
- 11 The supply disconnecting device has to be described in more details to clarify function, colour and use.
- 12 It makes a difference to have a safe stop or an isolation function; here is defined when a safe stop function only is allowed.
- 13 The main topic is "isolating" not only "safe stop" or any kind of "disconnecting or switching of by electronic devices".
- 14 New wording aligned with IEC 60204 series and other safety standards.
- 15 New wording aligned with IEC 60204 series and other safety standards.
- 16 RCDs and RCMs are state of the art for protective measures, here is described in detail how to use in different power systems.
- 17 A RCD type B can not be blocked by DC currents like RCD type A may be blocked in function.
- 18 Figure is updated to show more details of hoisting electrical equipment.
- 19 Text is re-organized for a better reading.
- 20 As hoisting machines are mostly designed of steel, here is defined which enclosures or other parts can also be used as a part of the protective conductors under which conditions and how they have to be connected to the protective bonding system.
- 21 New subclause is added for mobile hoisting machines with onboard power systems.
- 22 New text gives more detailed information on control power supplies.
- 23 Hoisting machines with different operating modes with different impacts on safety need a mode selector which not only can be a switch, but also other methods of mode selections which are described here.
- 24 IEC 62745 includes all requirements for cableless controls given in the IEC 60204-32:2008, so this Subclause 9.2.7 can mostly be deleted.

- 25 This subclause is reorganized for a better reading.
 - 26 This subclause is reorganized with new figures for a better reading and aligned with IEC 60204-1.
 - 27 Table 2 is shifted to Subclause 10.3.2 Colours.
 - 28 More detailed requirements are given in the additional clauses.
 - 29 Shifted from Subclause 11.5.4.
 - 30 Shifted to Subclause 11.5.2.
 - 31 This is not a cable manufacturing standard, so the different isolation materials are deleted to keep only the general requirements.
 - 32 Values in Table 7 are unchanged, only modifications of format and internal head lines are introduced.
 - 33 New subclause added with requirements to prevent eddy currents.
 - 34 Requirement is deleted as this standard is not dealing with household or similar purposes, the allowed combinations are given in requirements a) to j).
 - 35 The text is shortened and reorganized for a better reading.
 - 36 New subclause added including hazards from energy storage systems.
 - 37 The text is reorganized for a better reading.
 - 38 Clause 17 is reorganized and aligned with IEC 60204-1.
 - 39 Table 11 is aligned with IEC 60204-1.
 - 40 The reformulated Annex A is derived from new versions of IEC 60364.
 - 41 The text of Annex B is reformulated because this annex is informative.
 - 42 New Annex G (informative) is added to give measures and information.
 - 43 New Annex H (informative) is added to give information about hoisting machine documentation.
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INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Safety of machinery – Electrical equipment of machines –
Part 32: Requirements for hoisting machines**

**Sécurité des machines – Équipement électrique des machines –
Partie 32: Exigences pour les appareils de levage**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**SAFETY OF MACHINERY –
ELECTRICAL EQUIPMENT OF MACHINES –****Part 32: Requirements for hoisting machines****FOREWORD**

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IEC 60204-32 has been prepared by IEC technical committee 44: Safety of machinery – Electrotechnical aspects. It is an International Standard.

This third edition cancels and replaces the second edition published in 2008. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) alignment to the IEC 60204-1 sixth edition (2016) especially for:
 - requirements for earthing and bonding;
 - requirements for circuit protection;
 - consideration of use of Power Drive Systems;
 - protective bonding requirements and terminology;
 - requirements pertaining to safe torque off for PDS, emergency stop, and control circuit protection;
 - symbols for actuators of control devices;
- b) reference for high voltage electrical equipment;
- c) cableless control system requirements;
- d) EMC requirements;
- e) technical documentation requirements;
- f) general updating to current special national conditions, normative standards, and bibliographical references.

The text of this International Standard is based on the following documents:

Draft	Report on voting
44/1000/FDIS	44/1005/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

The following differing practices of a less permanent nature exist in the countries indicated below:

- 4.3.1: The voltage characteristics of electricity supplied by public distribution systems in Europe are given in EN 50160:2010.
- 5.1: Exception is not allowed (USA).
- 5.1: TN-C systems are not permitted in low-voltage installations in buildings (Norway).
- 5.2: Terminals for the connection of the protective earthing conductors may be identified by the colour green, the letters “G” or “GR” or “GRD” or “GND”, or the word “ground” or “grounding”, or with the graphical symbol IEC 60417-519:2002-10 or any combination (USA).
- 5.3.1: Isolation of the neutral conductor is mandatory in TN-systems (Norway).
- 6.3.3 b),
- 13.4.5 b),
- 18.2.1: TT power systems are not allowed (USA).
- 6.3.3,
- 18.2,
- Annex A: TN systems are not used. TT systems are the national standard (Japan)

- 6.3.3 b) The use of residual current protective devices with a rated residual operating current not exceeding 1 A is mandatory in TT systems as a means for fault protection by automatic disconnection of supply (Italy).
- 7.2.3: Disconnection of the neutral conductor is mandatory in a TN-S system (France).
- 7.2.3: Third paragraph: distribution of a neutral conductor with an IT system is not allowed (USA and Norway).
- 7.10: For evaluation of short circuit ratings, the requirements of UL 508A Supplement SB may be used (USA).
- 8.2.2: See IEC 60364-5-54:2011, Annex E List of notes concerning certain countries. Maximum nominal AC control circuit voltage is 120 V (USA).
- 9.1.2: Only stranded wires are allowed on machines, except for 0,2 mm² solid conductors within enclosures (USA).
- 12.2: The smallest power circuit conductor allowed on machines is 0,82 mm² (AWG 18).
- Table 5: Cross-sectional area is specified in NFPA 79 using American Wire Gauge (AWG) (USA). See Annex F.
- 13.2.2: For the protective conductor, the colour identification GREEN (with or without YELLOW stripes) is used as equivalent to the bicolour combination GREEN-AND YELLOW (USA and Canada).
- 13.2.3: The colour identification WHITE or GREY is used for earthed neutral conductors instead of the colour identification BLUE (USA and Canada).
- 15.2.2: First paragraph: Maximum value between conductors 150 V (USA).
- 15.2.2: Second paragraph, fifth bullet: The full load current rating of lighting circuits does not exceed 15 A (USA).
- 16.4: Nameplate marking requirements (USA).
- A.2.2.2: The permissible maximum value of R_A is regulated (e.g. when $U_0 > 300$ V, R_A shall be less than 10 Ω , when $U_0 < 300$ V, R_A shall be less than 100 Ω , U_0 is the nominal AC line to earth voltage in volts (V) (Japan).
- A.2.2.2: The maximum permissible value of R_A is 83 Ω (Netherlands).

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

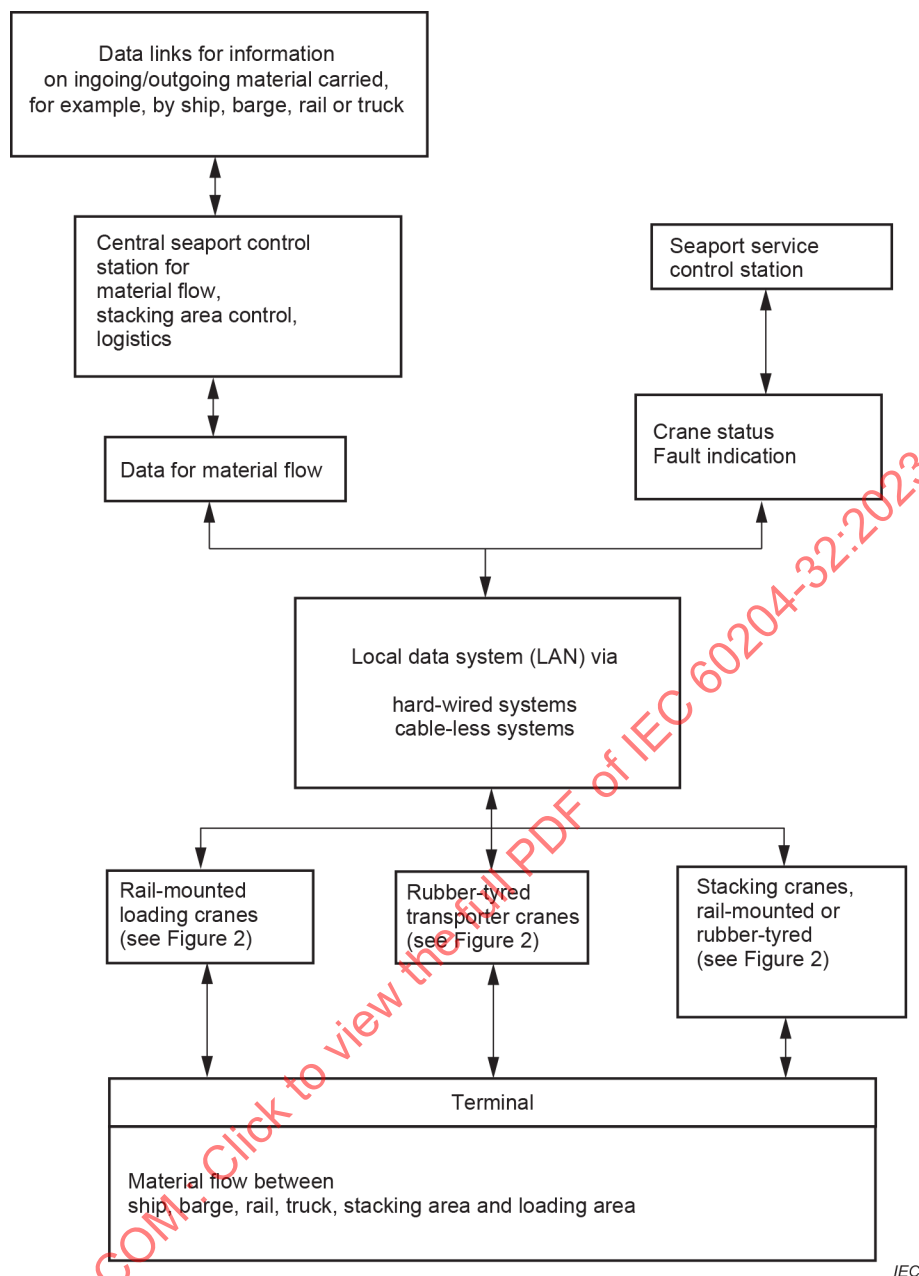
This part of IEC 60204 provides requirements and recommendations relating to the electrical equipment of hoisting machines so as to promote

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

It is important that high performance is not obtained at the expense of the essential factors mentioned above.

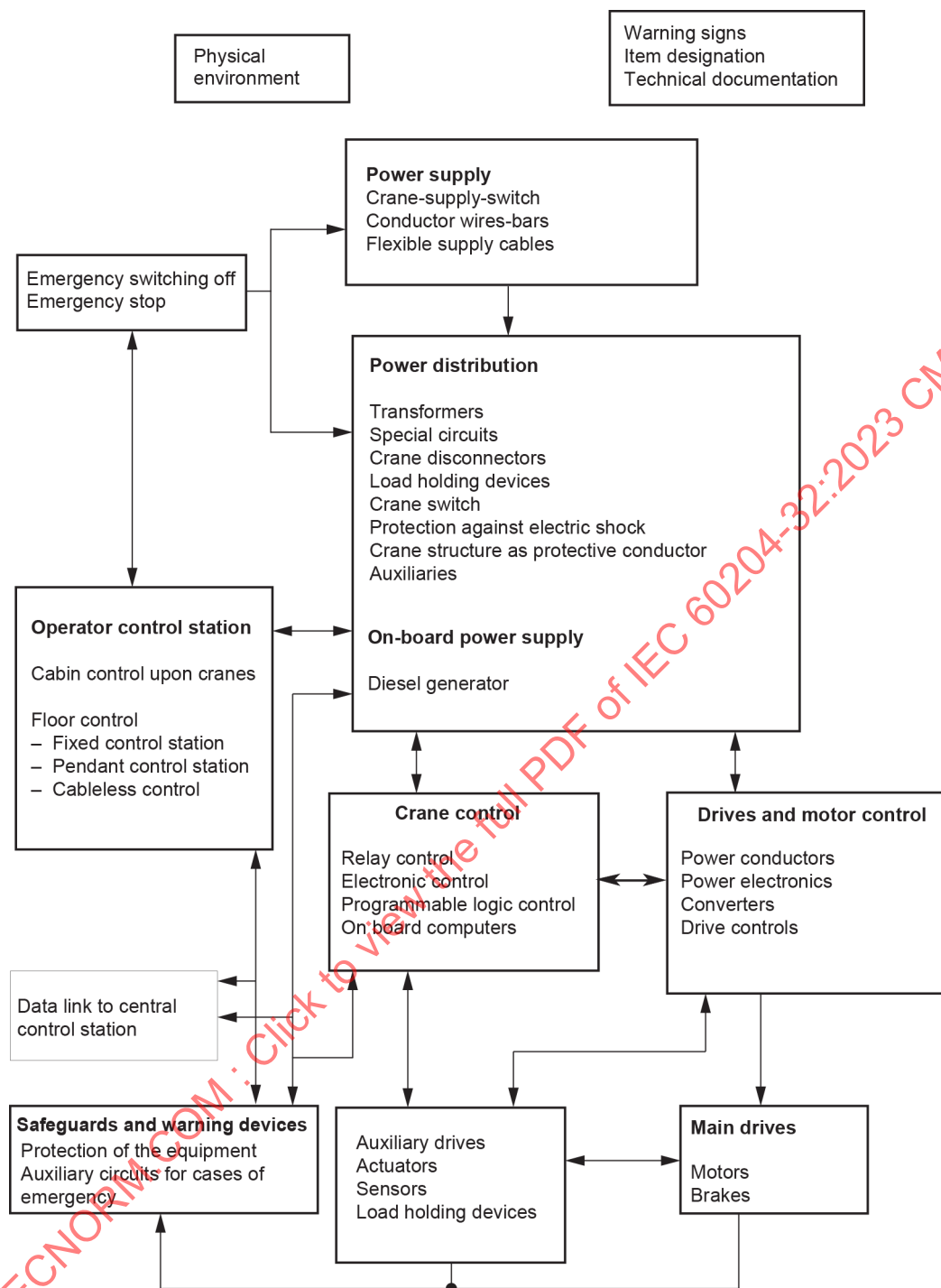
Figure 1 and Figure 2 have been provided as an aid to understanding the interrelationship of the various elements of a hoisting machine and its associated equipment. Figure 1 is an overall block diagram of a typical material handling system (a group of cranes working together in a coordinated manner) and Figure 2 is a block diagram of a typical crane and associated equipment showing the various elements of the electrical equipment addressed in this document.

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Figure 1 – Block diagram of combined working cranes in a typical material handling system in a seaport



IEC

Figure 2 – Block diagram of a typical crane and its associated electrical equipment

SAFETY OF MACHINERY – ELECTRICAL EQUIPMENT OF MACHINES –

Part 32: Requirements for hoisting machines

1 Scope

This part of IEC 60204 applies to electrical, electronic, programmable electronic equipment and systems to hoisting machines and related equipment, including a group of hoisting machines working together in a co-ordinated manner.

NOTE 1 In this document, the term “electrical” includes both electrical and electronic matters (i.e. “electrical equipment” means both the electrical, electronic and programmable electronic equipment).

NOTE 2 In the context of this document, the term “person” refers to any individual and includes those persons who are assigned and instructed by the user or user’s agent(s) in the use and care of the hoisting machine in question.

The equipment covered by this document commences at the point of connection of the supply to the electrical equipment of the hoisting machine (crane-supply-switch) and includes systems for power supply and control feeders situated outside of the hoisting machine, for example, flexible cables or conductor wires or conductor bars (see Figure 3).

NOTE 3 The requirements for the electrical supply installation of electrical equipment of a hoisting machine are given in IEC 60364.

This document is applicable to equipment or parts of equipment not exceeding 1 000 V AC or 1 500 V DC between lines and with nominal frequencies not exceeding 200 Hz.

NOTE 4 Special requirements for electrical equipment of hoisting machines intended to be operated at higher voltages can be found in IEC 60204-11.

This document 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 hoisting machine has unique requirements to be accommodated to provide adequate safety. This document does not cover noise risks.

Additional and special requirements can apply to the electrical equipment of hoisting machines including those that

- handle or transport potentially explosive material (e.g. paint or sawdust);
- are intended for use in potentially explosive and/or flammable atmospheres;
- have special risks when transporting or moving certain materials;
- are intended for use in mines.

For the purposes of this document, hoisting machines include cranes of all types, winches of all types and storage and retrieval machines. The following product groups are included:

- overhead travelling cranes;
- mobile cranes;
- tower cranes;
- slewing luffing cranes;
- gantry cranes;
- offshore cranes;

- floating cranes;
- winches of all types;
- hoists and accessories;
- loader cranes;
- cable cranes;
- load holding devices;
- storage and retrieval machines;
- monorail hoists;
- straddle carriers;
- rubber tired gantry cranes (RTGs).

NOTE 5 A definition of the different crane types can be found in ISO 4306-1.

This document does not cover individual items of electrical equipment other than their selection for use and their erection.

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.

IEC 60034-1:2017, *Rotating electrical machines – Part 1: Rating and performance*

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

IEC 60034-11, *Rotating electrical machines – Part 11: Thermal protection*

IEC 60068-2-27:2008, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60068-2-31:2008, *Environmental testing – Part 2-31: Tests – Test Ec: Rough handling shocks, primarily for equipment-type specimens*

IEC 60072-1, *Rotating electrical machines – Dimensions and output series – Part 1: Frame numbers 56 to 400 and flange numbers 55 to 1080*

IEC 60072-2, *Dimensions and output series for rotating electrical machines – Part 2: Frame numbers 355 to 1000 and flange numbers 1180 to 2360*

IEC 60072-3, *Dimensions and output series for rotating electrical machines – Part 3: Small built-in motors – Flange numbers BF10 to BF50*

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

IEC 60309-1, *Plugs, fixed or portable socket-outlets and appliance inlets for industrial purposes – Part 1: General requirements*

IEC 60364-1:2005, *Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions*

IEC 60364-4-41:2005, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*
IEC 60364-4-41:2005/AMD1:2017

IEC 60364-4-43:2008, *Low-voltage electrical installations – Part 4-43: Protection for safety – Protection against overcurrent*

IEC 60364-5-52:2009, *Low-voltage electrical installations – Part 5-52: Selection and erection of electrical equipment – Wiring systems*

IEC 60364-5-53:2019, *Low-voltage electrical installations – Part 5-53: Selection and erection of electrical equipment – Devices for protection for safety, isolation, switching, control and monitoring*

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

IEC 60364-6:2016, *Low-voltage electrical installations – Part 6: Verification*

IEC 60417, *Graphical symbols for use on equipment* (available at <https://www.graphical-symbols.info/equipment>)

IEC 60445:2021, *Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors*

IEC 60447:2004, *Basic and safety principles for man-machine interface, marking and identification – Actuating principles*

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

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

IEC 60755:2017, *General safety requirements for residual current operated protective devices*

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

IEC 60947-2:2016, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*

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

IEC 60947-4-1:2018, *Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters*

IEC 60947-5-1:2016, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

IEC 60947-5-5, *Low-voltage switchgear and controlgear – Part 5-5: Control circuit devices and switching elements – Electrical emergency stop device with mechanical latching function*

IEC 60947-6-2, *Low-voltage switchgear and controlgear – Part 6-2: Multiple function equipment – Control and protective switching devices (or equipment) (CPS)*

IEC 61140, *Protection against electric shock – Common aspects for installations and equipment*

IEC 61204-7, *Low-voltage switch mode power supplies – Part 7: Safety requirements*

IEC 61310 (all parts), *Safety of machinery – Indication, marking and actuation*

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

IEC 61557-3, *Electrical safety in low voltage distribution systems up to 1 000 V AC and 1 500 V DC – Equipment for testing, measuring or monitoring of protective measures – Part 3: Loop impedance*

IEC 61557-9:2014, *Electrical safety in low voltage distribution systems up to 1 000 V AC and 1 500 V DC – Equipment for testing, measuring or monitoring of protective measures – Part 9: Equipment for insulation fault detection in IT systems*

IEC 61558-1, *Safety of transformers, reactors, power supply units and combinations thereof – Part 1: General requirements and tests*

IEC 61558-2-2, *Safety of power transformers, power supplies, reactors and combinations thereof – Part 2-2: Particular requirements and tests for control transformers and power supply units incorporating control transformers*

IEC 61558-2-6, *Safety of transformers, reactors, power supply units and combinations thereof – Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers for general applications*

IEC 61558-2-16, *Safety of transformers, reactors, power supply units and combinations thereof – Part 2-16: Particular requirements and tests for switch mode power supply units and transformers for switch mode power supply units for general applications*

IEC 61800-3, *Adjustable speed electrical power drive systems – Part 3: EMC requirements and specific test methods for PDS and machine tools*

IEC 61800-5-1, *Adjustable speed electrical power drive systems – Part 5-1: Safety requirements – Electrical, thermal and energy*

IEC 61800-5-2, *Adjustable speed electrical power drive systems. – Part 5-2: Safety requirements – Functional*

IEC 61984, *Connectors – Safety requirements and tests*

IEC 62023, *Structuring of technical information and documentation*

IEC 62061, *Safety of machinery – Functional safety of safety-related control systems*

IEC 62745:2017, *Safety of machinery – Requirements for cableless control systems of machinery*

ISO 7010, *Graphical symbols – Safety colours and safety signs – Registered safety signs*, available at <https://www.iso.org/obp>

ISO 12100:2010, *Safety of machinery – General principles for design – Risk assessment and risk reduction*

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

ISO 13849-2, *Safety of machinery – Safety-related parts of control systems – Part 2: Validation*

ISO 13850:2015, *Safety of machinery – Emergency stop function – Principles for design*

ISO 13857, *Safety of machinery – Safety distances to prevent hazard zones being reached by upper and lower limbs*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions 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>

3.1.1

actuator

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

Note 1 to entry: The actuator may take the form of a handle, knob, push-button, roller, plunger, etc.

Note 2 to entry: There are some actuating means that do not require an external actuating force but only an action, for example, touchscreens.

Note 3 to entry: See also 3.1.53.

3.1.2

ambient temperature

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

3.1.3

apparatus

finished device or combination thereof made commercially available as a single functional unit, intended for the end user and liable to generate electromagnetic disturbance, or the performance of which is liable to be affected by such disturbance

3.1.4

barrier

part providing protection against contact by a human being or livestock with hazardous-live parts from any usual direction of access

[SOURCE: IEC 60050-195:2021, 195-06-15, modified – The term "protective barrier" has been replaced with "barrier".]

3.1.5

basic drive module

BDM

electronic power converter and related control, connected between an electric supply and a motor

[SOURCE: IEC 61800-2:2021, 3.4]

3.1.6

basic protection

protection against electric shock under fault-free conditions

Note 1 to entry: Previously referred to as “protection against direct contact”

[SOURCE: IEC 60050-195:1998, 195-06-01, modified – The note to entry has been added.]

3.1.7

cabin-controlled hoisting machine

hoisting machine operated from a cabin permanently attached to the hoisting machine

3.1.8

cable tray

cable support consisting of a continuous base with raised edges but no covering

Note 1 to entry: A cable tray can be perforated or mesh.

[SOURCE: IEC 60050-826:2022, 826-15-08]

3.1.9

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/or for the accommodation of other electrical equipment including information technology equipment

[SOURCE: IEC 60050-826:2022, 826-15-04]

3.1.10

concurrent

<two or more control devices> existing in an actuated condition at the same time, but not necessarily synchronously

3.1.11

conductor wire

conductor bar

conductor rail

wire, conductive bar or rail of a feeder system having a sliding current collector

3.1.12

conduit

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

Note 1 to entry: Conduits should be sufficiently close-jointed so that the insulated conductors and/or cables can only be drawn in and not inserted laterally.

[SOURCE: IEC 60050-826:2022, 826-15-03]

3.1.13

control circuit

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

3.1.14

control device

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

3.1.15**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

[SOURCE: IEC 60050-441:1984, 441-11-03]

3.1.16**control station****operator control station**

assembly of one or more control actuators fixed on the same panel or located in the same enclosure

Note 1 to entry: A control station may also contain related equipment, for example, potentiometers, signal lamps, instruments, display devices, etc.

Note 2 to entry: A definition of "actuator" is given in 3.1.1.

3.1.17**controlled stop**

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

3.1.18**crane**

machine for hoisting/lowering and horizontally relocating suspended loads

3.1.19**crane-disconnector**

disconnecting device installed on a hoisting machine for disconnecting (isolating) a supply circuit (e.g. for repair or maintenance work)

3.1.20**crane-supply-switch**

disconnecting (isolating) and switching device used to disconnect the hoisting machine from the incoming supply

3.1.21**crane-switch**

switching device designed to break the electrical power supply to the connected drives (e.g. for use in cases of emergency stop)

3.1.22**current-carrying capacity**

ampacity (US)

maximum value of electric current which can be carried continuously by a conductor, a device or an apparatus, under specified conditions without its steady-state temperature exceeding a specified value

[SOURCE: IEC 60050-826:2022, 826-11-13]

3.1.23**direct contact**

electric contact of human beings or livestock with live parts

[SOURCE: IEC 60050-195:2021, 195-06-03.]

3.1.24

direct opening action

<contact element> 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)

[SOURCE: IEC 60947-5-1:2016, K.2.2]

3.1.25

disconnecting device

device which provides, in the open position, an isolating distance in accordance with specified requirements

3.1.26

duct

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

Note 1 to entry: Conduits (3.1.12), cable trunking systems (3.1.9) and underfloor channels are types of duct.

3.1.27

earth

local earth

ground (US)

local ground (US)

part of the Earth which is in electric contact with an earth electrode and that has an electric potential not necessarily equal to zero

[SOURCE: IEC 60050-195:2021, 195-01-03, modified – The terms "earth" and "ground" have been added.]

3.1.28

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

3.1.29

electronic equipment

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

3.1.30

emergency stop device

manually actuated control device used to initiate an emergency stop function

[SOURCE: ISO 13850:2015, 3.3]

3.1.31

emergency switching-off device

manually actuated control device used to switch off or to initiate the switching off of 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

3.1.32

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 use of a key or tool to open a door or remove a barrier, and which is clearly marked by appropriate warning signs

3.1.33**enclosure**

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

Note 1 to entry: The definition taken from the existing IECV needs the following explanations within the scope of this document.

- 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 hoisting machine or separate from the hoisting machine;
 - a compartment consisting of an enclosed space within the hoisting machine structure (e.g. box girder).

3.1.34**electrical equipment**

items used in connection with the utilisation of electricity by machines or parts of machines, for example material, fittings, devices, components, appliances, fixtures, apparatus, and similar

3.1.35**equipotential bonding**

set of electric connections intended to achieve equipotentiality between conductive parts

[SOURCE: IEC 60050-195:2021, 195-01-10]

3.1.36**exposed conductive part**

conductive part of equipment that can be touched and that is not live under normal conditions, but that can become live when basic insulation fails

[SOURCE: IEC 60050-195:2021, 195-06-10]

3.1.37**extraneous conductive part**

conductive part not forming part of the electrical installation and that is likely to introduce an electric potential, generally the electric potential of a local earth

[SOURCE: IEC 60050-195:2021, 195-06-11]

3.1.38**failure**

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

Note 1 to entry: After the failure, the item is in fault condition.

Note 2 to entry: A failure is an event, as distinguished from a fault, which is a state.

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

Note 4 to entry: In practice the terms “fault” and “failure” are often used synonymously.

[SOURCE: IEC 60050-845:2020, 845-27-105, modified – A fourth note to entry has been added.]

3.1.39

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 to entry: A fault is often the result of a failure of the item itself, but may exist without prior failure.

3.1.40

fault protection

protection against electric shock under single-fault conditions

Note 1 to entry: Previously referred to as “protection against indirect contact”.

[SOURCE: IEC 60050-195:2021, 195-06-02, modified – A note to entry has been added.]

3.1.41

first environment

environment that includes domestic premises, it also includes establishments directly connected without intermediate transformers to a low-voltage power supply network which supplies buildings used for domestic purposes

Note 1 to entry: Houses, apartments, commercial premises or offices in a residential building are examples of first environment locations.

3.1.42

fixed installation

particular combination of several types of apparatus and, where applicable, other devices, which are assembled, installed and intended to be used permanently at a predefined location

3.1.43

functional bonding

equipotential bonding necessary for proper functioning of electrical equipment

3.1.44

guard

part of a hoisting machine specifically used to provide protection by means of a physical barrier

3.1.45

hand-held direct-control device

manually operated switching device, the enclosure of which is portable by hand during operation, acting direct on a power circuit without a control circuit

3.1.46

hazard

potential source of harm

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, fire hazard).

Note 2 to entry: The hazard envisaged by this definition either

- is permanently present during the intended use of the machine (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 – Note 3 has been deleted.]

3.1.47**indirect contact**

electric contact of human beings or livestock with exposed conductive parts that have become live under fault conditions

[SOURCE: IEC 60050-195:2021, 195-06-04]

3.1.48**inductive power supply system**

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

Note 1 to entry: The track conductor and the pick-up are analogous to the primary and secondary of a transformer, respectively.

3.1.49**instructed person****electrically instructed person**

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

[SOURCE: IEC 60050-195:2021, 195-04-02]

3.1.50**interlock**

arrangement of devices operating together to

- prevent hazardous situations,
- prevent damage to equipment or material,
- prevent specified operations,
- ensure correct operations

3.1.51**limiting device**

device which prevents a hoisting machine or a hoisting machine element from exceeding a designed limit (e.g. space limit, pressure limit, load limit, load moment limit)

[SOURCE: ISO 12100 3.28.8, modified – In the definition, "machine or hazardous machine condition(s)" has been replaced by "hoisting machine or a hoisting machine element" and "load limit" has been added.]

3.1.52**live part**

conductive part intended to be energized under normal operating conditions, including the neutral conductor and mid-point conductor, but excluding the PEN conductor, PEM conductor and PEL conductor

[SOURCE: IEC 60050-195:2021, 195-02-19]

3.1.53**machine actuator**

power mechanism used to effect motion of the hoisting machine (for example, motor, solenoid, pneumatic or hydraulic cylinder)

3.1.54
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

Note 1 to entry: The term "machinery" also covers an assembly of machines which, in order to achieve the same target, are arranged and controlled so that they function as an integral whole

Note 2 to entry: The term "component" is used here in a general sense and does not refer only to electrical components.

3.1.55
manually controlled hoisting machine

hoisting machine with continuous manual control of the load and with the load continuously visible to the operator

3.1.56
marking

signs or inscriptions primarily for the purpose of identifying equipment, components and/or devices

3.1.57
neutral conductor
N

conductor electrically connected to the neutral point and capable of contributing to the distribution of electrical energy

[SOURCE: IEC 60050-195:2021, 195-02-06]

3.1.58
obstacle

part preventing unintentional direct contact by a human being or livestock with live parts, but not preventing such contact by deliberate action

[SOURCE: IEC 60050-195:2021, 195-06-16, modified – The term "protective obstacle, <electrically>" has been replaced with "obstacle".]

3.1.59
overcurrent

electric current the values of which exceeds a specific limiting value

[SOURCE: IEC 60050-151:2001, 151-15-28]

3.1.60
overload

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 1 to entry: "Overload" should not be used as a synonym for "overcurrent".

Note 2 to entry: In hoisting machines the term "overload" is also used for mechanical overload, which may or may not cause an electrical overload.

3.1.61**plug/socket combination**

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

Note 1 to entry: 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.

3.1.62**power circuit**

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

3.1.63**Power Drive System****PDS**

system consisting of one or more complete drive module(s) (CDM) and a motor or motors

[SOURCE: IEC 61800-2:2021, 3.52]

3.1.64**PDS of category 1**

PDS intended for use in the first environment

3.1.65**PDS of category 2**

PDS, which is neither a plug-in device nor a movable device and, when used in the first environment, is intended to be installed and commissioned only by a professional

Note 1 to entry: A professional is a person or an organization having necessary skills in installing and/or commissioning power drive systems, including their EMC aspects.

3.1.66**PDS of category 3**

PDS intended for use in the second environment and not intended for use in the first environment

3.1.67**PDS of category 4**

PDS of rated voltage equal to or above 1 000 V, or rated current equal to or above 400 A, or intended for use in complex systems in the second environment

3.1.68**protective bonding**

equipotential bonding for protection against electric shock

Note 1 to entry: Measures for protection against electric shock can also reduce the risk of burns or fire.

Note 2 to entry: Protective bonding can be achieved with protective conductors and protective bonding conductors and by conductive joining of conductive parts of the machine and its electrical equipment.

3.1.69**protective bonding circuit**

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

3.1.70

protective conductor

conductor providing a primary fault current path from the exposed conductive parts of the electrical equipment to a protective earthing (PE) terminal

3.1.71

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

3.1.72

reference designation

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

3.1.73

risk

combination of the probability of occurrence of harm and the severity of that harm

Note 1 to entry: "Harm" refers to physical injury or damage to health.

[SOURCE: ISO 12100:2010, 3.12, modified – Note 1 to entry has been added.]

3.1.74

safeguard

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

3.1.75

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

[SOURCE: ISO 12100:2010, 3.21]

3.1.76

safety function

function of a machine whose failure can result in an immediate increase of the risk(s)

[SOURCE: ISO 12100:2010, 3.30]

3.1.77

second environment

environment that includes all establishments other than those directly connected to a low voltage power supply network which supplies buildings used for domestic purposes

Note 1 to entry: Industrial areas, technical areas of any building fed from a dedicated transformer are examples of second environment locations.

3.1.78

servicing level

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

3.1.79

short-circuit current

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

[SOURCE: IEC 60050-441:1984, 441-11-07]

3.1.80**short-circuit current rating**

value of prospective short-circuit current that can be withstood by the electrical equipment for the total operating time (clearing time) of the short-circuit protective device (SCPD) under specified conditions

3.1.81**skilled person****electrically skilled person**

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

[SOURCE: IEC 60050-195:2021, 195-04-01, modified – Training is an additional and necessary condition.]

3.1.82**supplier**

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

Note 1 to entry: The user organization may also act in the capacity of a supplier to itself.

3.1.83**switching device**

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

[SOURCE: IEC 60050-441:1984, 441-14-01, modified – In the definition, "and/" has been added.]

3.1.84**terminal**

part of an equipment or a component to which a conductor is attached, providing a re-usable connection

[SOURCE: IEC 60050-442:1998, 442-06-05, modified – In the definition, "or a component" has been added.]

3.1.85**uncontrolled stop**

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

Note 1 to entry: This definition does not imply any particular state of other (e.g. non-electrical) stopping devices, for example, mechanical or hydraulic brakes that are outside the scope of this document.

3.1.86**user**

entity who utilizes the hoisting machine and its associated electrical equipment

3.2 Abbreviated terms

AWG	American Wire Gauge
AC	Alternating Current
BDM	Basic Drive Module
CCS	Cableless Control System
DC	Direct Current
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference

PDS	Power Drive System
PELV	Protective Extra-Low Voltage
RCD	Residual Current protective Device
RMS	Root Mean Square
SCPD	Short-Circuit Protective Device
SELV	Safe Extra-Low Voltage
STO	Safe Torque Off

4 General requirements

4.1 General considerations

This document is intended to apply to electrical equipment used with a wide variety of hoisting machines and with a group of hoisting 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 hoisting machine. This will

- identify the need for risk reduction, and
- determine adequate risk reductions, and
- determine the necessary protective measures

for persons who can be exposed to those hazards, while still maintaining an appropriate level of performance of the hoisting 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 fire of electrical origin;
- failures or faults in control circuits (or components and devices associated with those circuits) resulting in the malfunctioning of the hoisting machine;
- disturbances or disruptions in power sources as well as failures or faults in the power circuits resulting in the malfunctioning of the hoisting machine;
- loss of continuity of circuits that can result in a failure of a safety function, for example those that depend on sliding or rolling contacts;
- electrical disturbances – for example, electromagnetic, electrostatic – either from outside the electrical equipment or internally generated, resulting in the malfunctioning of the hoisting machine;
- release of stored energy (either electrical or mechanical) resulting in, for example, electric shock, unexpected movement that can cause injury;
- acoustic noise and mechanical vibration 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.

The design and development process shall identify hazards and the risks arising from them. Where the hazards cannot be removed and/or those 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, flashing beacons, warning notices or signs to raise of the risks) shall be provided where further risk reduction is necessary. In addition, working procedures that reduce risk can be necessary.

It is recommended that, where the user is known, Annex B be used to facilitate an exchange of information 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 hoisting machine (or group of hoisting machines) and the application;
- facilitate maintenance and repair; and
- improve the reliability and ease of operation.

NOTE The use of Annex B can also be useful to determine if a catalogued hoisting machine is suitable for the intended use.

4.2 Selection of equipment

4.2.1 General

Electrical components and devices shall:

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

4.2.2 Selection of power contactors

The contactors with their associated short-circuit protective devices shall have type "2" coordination in accordance with IEC 60947-4-1:2018, 8.2.5.1.

Contactors which perform the stopping function of motion drives, initiated by safety-related control circuits, shall be selected and arranged with other equipment in such a way that contact welding either will not occur or will not prevent the emergency stop function. The supplier's recommendations should be followed (see also 7.2.9).

Contactors directly controlling motions should have mechanical and electrical lifetime regarding requirements for application in use.

4.2.3 Switchgear

In addition to the requirements of this document, depending upon the hoisting machine, its intended use and its electrical equipment, the designer may select parts of the electrical equipment of the hoisting machine that conform to relevant parts of the IEC 61439 series.

4.2.4 Selection of PDS

For the PDSs or part of PDS, when it will be incorporated into electrical equipment of hoisting machines, IEC 61800-5-1 shall apply.

4.3 Electrical supply

4.3.1 General requirements

The electrical equipment shall be designed to operate correctly with the conditions of the supply at the point of supply (i.e. at the crane-supply-switch, see Figure 3):

- as specified in 4.3.2 or 4.3.3; or
- as otherwise specified by the user; or
- as specified by the supplier of a special source of supply (see 4.3.4).

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 to exceed 12 % of the total RMS voltage between live conductors for the sum of the second through to the thirtieth harmonic.
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.
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.

NOTE In some semiconductor converter drives with power feedback, voltage interruptions as short as 3 ms or less can cause conduction-through and fuse blowing.

Voltage dips	Voltage dips shall not exceed 20 % of the RMS 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 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. There shall be more than 1 s between successive interruptions.

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

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

4.3.4 Special supply systems

For special supply systems (e.g. on-board generators, DC bus, etc.), 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 hoisting machines covered by this document. When special conditions apply or the limits specified are exceeded, an exchange of information between user and supplier (see 4.1) is recommended (see Annex B).

4.4.2 Electromagnetic compatibility (EMC)

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

For electrical equipment of hoisting machines including PDS or part of PDS, IEC 61800-3 shall be applied.

NOTE The generic EMC standards IEC 61000-6-1 or IEC 61000-6-2 and IEC 61000-6-3 or IEC 61000-6-4 or IEC 61000-6-8 give general EMC emission and immunity limits.

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 in ambient air temperatures outside of enclosures (cabinet or box) between 0 °C and +40 °C. For very hot environments (e.g. hot climates, steel mills, paper mills) and for cold environments, additional measures are recommended (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 are 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 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.

For equipment to be used at higher altitudes, it is necessary to take into account changes in parameters for example, the reduction of:

- the dielectric strength; and
- the switching capability of the devices; and
- the cooling effect of the air.

Other parameters of different components can also alter with altitude. When the characteristic of a component can be altered by the altitude, an appropriate correction factor shall be applied according to the information of its manufacturer.

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 (e.g. dust, acids, corrosive gases, salts) that can be present in the physical environment in which the electrical equipment is to be installed.

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.

4.4.8 Vibration, shock, and bump

Undesirable effects of vibration, shock and bump (including those generated by the hoisting 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 sources of vibration, or by provision of anti-vibration mountings.

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 $-25\text{ }^{\circ}\text{C}$ to $+55\text{ }^{\circ}\text{C}$ and for periods not exceeding 24 h at up to $+70\text{ }^{\circ}\text{C}$. 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 hoisting machine for transport, or that is independent of the hoisting machine, shall be provided with suitable means for handling, including where necessary means for handling by cranes or similar equipment (see also 13.4.6).

4.7 Installation

Electrical equipment shall be installed in accordance with the electrical equipment supplier's instructions.

NOTE Annex C and Annex G give additional information.

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

5.1 Incoming supply conductor terminations

Where practicable, the electrical equipment of a hoisting 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 hoisting machine. For large complex hoisting machines, there may be a need for more than one incoming supply (see 5.3.5.1).

Unless a plug is provided with the hoisting machine for the connection to the supply (see 5.3.2 e)), it is recommended that the supply conductors are terminated at the crane-supply-switch. 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 hoisting 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. The neutral terminal may be provided as part of the supply disconnecting device.

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 supply (see Figure 3) to the hoisting machine for TN-C systems provided they are in accordance with 12.7.2.

Terminals for the incoming supply connection shall be clearly identified in accordance with IEC 60445:2021. For the identification of the external protective conductor terminal, see 5.2.

5.2 Terminal for connection of the external protective conductor

For each incoming supply, a terminal shall be provided in the same compartment as the associated line conductor terminals (see 8.2.1) for connection of the hoisting machine to the external protective conductor.

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

Table 1 – Minimum cross-sectional area of protective copper conductors

Cross-sectional area of line conductors S mm ²	Minimum cross-sectional area of the corresponding protective conductor S_p 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 and type shall be selected accordingly (see also 8.2.2).

At each incoming supply point, the terminal for connection of the external protective conductor shall be marked or labelled with the letters PE (see IEC 60445:2021).

5.3 Supply disconnecting and switching devices

5.3.1 General

The functions of supply disconnection and/or switching are performed by the following devices:

- crane-supply-switch (see 5.3.5);
- crane-disconnector (see 5.3.6);
- crane-switch (see 5.3.7).

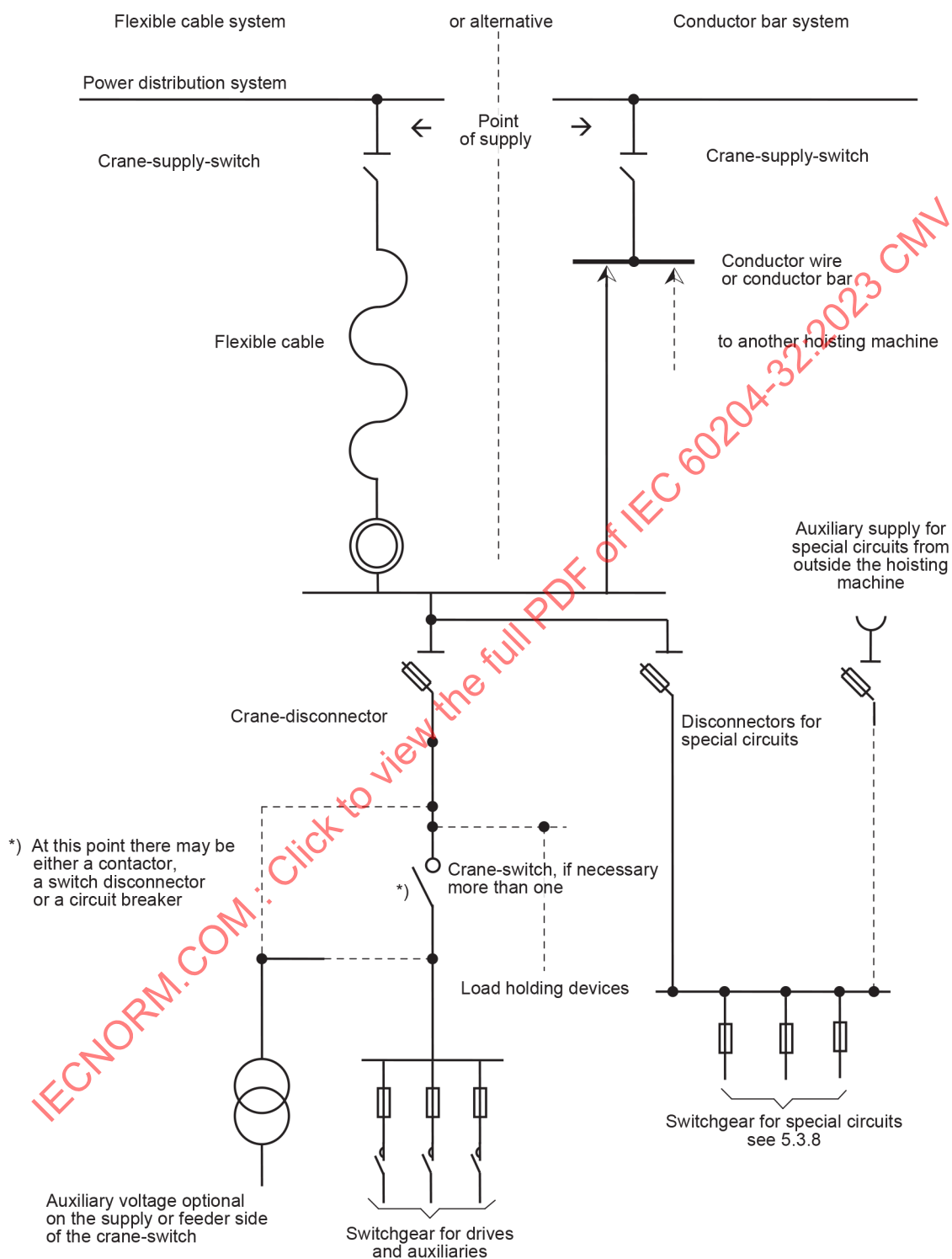
See also Figure 3.

5.3.2 Type

The supply disconnecting and switching devices can 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 60947-2:2016;
- d) 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;

- e) a plug/socket combination for a flexible cable supply.
- f) control and protective switching device suitable for isolation, in accordance with IEC 60947-6-2.



IEC

Figure 3 – Examples of electrical supply systems

5.3.3 Requirements

When the supply disconnecting and switching 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 (2002-10) and IEC 60417-5007 (2002-10), 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 (e.g. handle) (exception: power-operated switchgear need not be operable from outside the enclosure where there are other means to open it).
- Be provided with a means permitting it to be locked in the OFF (isolated) position (e.g. 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 other loads. The calculated breaking capacity may be reduced by the use of a proven diversity factor. Where motor(s) are supplied by converter(s) or similar devices, the calculation should take into account the possible effect on the required breaking capacity.

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

- Have the breaking 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 other loads. The calculated breaking capacity may be reduced by the use of a proven diversity factor. When the interlocked switching device is electrically operated (e.g. a contactor), it shall have an appropriate utilization category. Where motor(s) are supplied by converter(s) or similar devices, the calculation should take into account the possible effect on the required breaking capacity.
- Fulfil the requirements 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 utilization 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 of the supply disconnecting device

The operating means (e.g. a handle) of the supply disconnecting and switching device shall be external to the enclosure of the electrical equipment.

Exception: power-operated switchgear need not be provided with a handle outside the enclosure where other means (e.g. pushbuttons) are provided to open the supply disconnecting device from outside the enclosure.

The operating means of the supply disconnecting device and switching 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 Further information about direction of operation is available in IEC 61310-3.

Where the external operating means is not intended for emergency operations:

- it is recommended that it be coloured BLACK or GREY (see 10.2);
- a supplementary cover or door that can be readily opened without the use of a key or tool may be provided, for example for protection against environmental conditions or mechanical damage. Such a cover/door shall clearly show that it provides access to the operating means. This can be achieved, for example, by use of the relevant symbol IEC 60417-6169-1 (2012-08) (Figure 4) or IEC 60417-6169-2 (2012-08), (Figure 5).

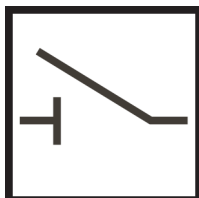


Figure 4 – Disconnector isolator

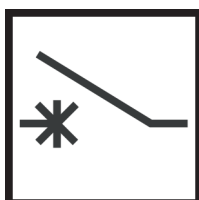


Figure 5 – Disconnecting circuit breaker

5.3.5 Crane-supply-switch

5.3.5.1 General

The following 5.3.5.1 to 5.3.5.3 do not apply to hoisting machines having on-board power supplies and without an alternative power supply from the outside.

Crane-supply-switches shall be provided

- for disconnecting (isolating) the conductor wires or conductor bars or cables to which the hoisting machine(s) is connected from the incoming supply for repair and maintenance works (e.g. on the conductor wires to the hoisting machine(s)); and
- where required for emergency stop and/or emergency switching-off (see 9.2.5.4).

Where two or more incoming supplies are used, a crane-supply-switch shall be provided for each supply, together with protective interlocks to ensure their correct operation.

The requirements of 5.6 shall apply as appropriate to crane-supply-switches.

5.3.5.2 Type

The crane-supply-switch shall be one of the types specified in 5.3.2.

In the case of hoisting machines on construction sites, equipment on the site distribution board may be used to achieve the function of the crane-supply-switch. The requirement of 5.6 shall be fulfilled by locking regardless of whether or not the disconnecting means is under immediate supervision.

5.3.5.3 Requirements

In the case of a single hoisting machine, the breaking capacity shall be sufficient to switch off the sum of the current under stalled rotor condition of the largest drive and the normal running currents of the other drives that can be operating at the same time.

NOTE If there is more than one hoisting machine on one common power supply according to the given service conditions, a proven simultaneity factor can be used.

If the crane-supply-switch performs the emergency switching-off function according to 9.2.5.4.3, it shall be capable of being opened (remotely or directly) from an easily accessible place(s) close to the hoisting machine.

The reconnection of a crane-supply-switch that has been remotely operated by an emergency switching-off device shall only be possible after the resetting of the emergency switching-off device(s).

Where a conductor wire or conductor bar is fed by several crane-supply-switches connected in parallel, they shall be provided with protective interlocks to ensure their correct operation.

It is recommended that the crane-supply-switch used to energize an unprotected conductor wire, or conductor bar, or a remote control for the crane-supply-switch be so located that as much as possible of the conductor wire or conductor bar is visible from that place of operation.

The above requirements should also apply in special cases, for example, where

- there are two main supply conductor wires or conductor bars or conductor systems, either of which may be used for supplying the hoisting machine(s); or
- a main supply conductor wire or conductor bar is divided into isolated sections.

In cases where these requirements cannot be fulfilled, the necessary safety shall be provided by other measures.

5.3.6 Crane-disconnector

5.3.6.1 General

A hoisting machine shall be equipped with a single crane-disconnector to enable the electrical equipment to be isolated for maintenance and repair purposes, and to prevent unexpected start-up during mechanical work on the hoisting machine, except under the following circumstances.

- A crane-disconnector is not required if there are no connections and branches in the wiring system between the intended crane-disconnector position and the crane-switch specified in 5.3.7, and the crane-switch performs the functions of the crane-disconnector and conforms to the requirements of 5.6.
- A crane-disconnector is not required for a single hoisting machine which is floor-controlled, and where the crane-supply-switch performs this function.

NOTE A floor-controlled hoisting machine is operated from a suspended pendant control station, a remote fixed control station, or a portable control station.

- A crane-disconnector is not necessary in cases where the voltage can be reduced to, and maintained at, zero by other means (e.g. locking off a diesel generator fuel supply or starter mechanism, etc.).

- On hoisting machines with power supplied at voltages of more than 1 kV AC and having one or more transformers installed on the hoisting machine, supplying a low-voltage system, one or more crane-disconnectors may be required on the secondary side of each transformer to isolate the low-voltage sections (see also 5.5). Circuits associated with each crane-disconnector shall be clearly identifiable, for example, by
 - separation, or
 - barriers, or
 - marking and labelling.

Preference should be given to the disconnection of a hoisting machine using only one crane-disconnector.

5.3.6.2 Type

Where provisions are made against both inadvertent and unauthorized opening, the crane-disconnector shall, as a minimum, conform to the requirements for disconnectors given in IEC 60947-3. Otherwise, it shall meet the requirements for switch-disconnectors given in IEC 60947-3. The actuator of the crane-disconnector shall conform to the requirements of 5.3.4.

Removable collectors or plug/socket combinations may be used as crane-disconnectors when they perform the same function.

On hoisting machines with an alternative power-supply system, the changeover switch of the supplies may be used as a crane-disconnector if it has a neutral off-position and meets the requirements of 5.3.6.

5.3.6.3 Requirements

The requirements of 5.4, 5.5 and 5.6 shall apply as appropriate.

5.3.7 Crane-switch

5.3.7.1 General

Each hoisting machine shall have one or more crane-switches, operable from the operating control station, for emergency stop of all motion drives and, where necessary, for interrupting the electrical power supply to other equipment.

Load holding devices that cannot continue to hold the load when de-energized (e.g. magnets, pneumatic holding devices) shall be supplied from the supply side of the crane-switch.

Exceptions. Where the emergency stop function is provided by other means, a crane-switch is not required for the following:

- for hoisting machines on which only the hoisting mechanism is power-operated;
- on floor-controlled monorail hoists when the trolley travel is powered by hand or by an electric motor rated at not more than 500 W.

5.3.7.2 Type

The crane-switch shall as a minimum meet the requirements for switches given in IEC 60947-3. This requirement can be fulfilled by one of the devices specified in 5.3.2 a) or c). Contactors selected in accordance with 4.2.2 and used in combination with disconnecting devices may also be used.

5.3.7.3 Requirements

The requirements of 5.3.3 and 5.3.4 shall apply as appropriate. The crane-switch can operate very frequently. All the components (e.g. charging circuitries) shall be selected to allow foreseen switching frequency including the use in commissioning phase.

5.3.8 Excepted circuits

Excepted circuits, which need to be operational during repair and maintenance work, shall be supplied from the supply side of the crane-disconnector specified in 5.3.6 using a dedicated disconnector (see Figure 3) that conforms to the requirements of 5.6.

Excepted circuits may include but are not limited to the following:

- circuits for plug and socket-outlets and lighting circuits;
- circuits for lifts, repair and maintenance tools and repair cranes installed in hoisting machines;
- circuits for heating, air conditioning and ventilation;
- circuits for electrical equipment fulfilling safety measures, for example anti-collision device, aviation lighting;
- circuits for fire alarm systems;
- communications circuits, data links or program storage devices;
- undervoltage protection circuits that are only provided for automatic tripping in the event of supply failure;
- control circuits for interlocking.

Excepted circuits shall be so designed and installed that their operation during repair and maintenance work on the hoisting machine does not use unprotected conductor wires, conductor bars or slip-ring assemblies.

Excepted circuits shall be identifiable by

- permanent warning label(s) placed in proximity to the crane-disconnector;
- a corresponding statement included in the maintenance manual; and one or more of the following shall apply:
 - the conductors are identified by colour taking into account the recommendation of 13.2.4;
 - excepted circuits are separated from other circuits;
 - excepted circuits are identified by permanent warning label(s).

5.4 Devices for removal of power for prevention of unexpected start-up

Devices for removal of power for the prevention of unexpected start-up shall be provided (e.g. where, during maintenance, a start-up of the hoisting machine or part of it can create a hazard). The crane-disconnector (see 5.3.6) fulfils that function for the complete hoisting machine. Where it is necessary to work on individual parts of a hoisting machine, additional devices for switching off shall be provided for each part requiring separate disconnection.

Such devices shall be appropriate and convenient for their intended use, shall be suitably placed and readily identifiable as to their function and purpose.

NOTE 1 This document does not address all provisions for prevention of unexpected start-up. See ISO 14118.

NOTE 2 Removal of power means removal of the connection to the source of electrical energy but does not imply isolation.

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).

NOTE 3 Further information on the location and actuation of devices such as those used for the prevention of unexpected start-up is provided in ISO 14118.

The following devices that fulfil the isolation function may be provided for these purposes:

- devices described in 5.3.2;
- disconnectors, withdrawable fuse links and withdrawable links only if located in an enclosed electrical operating area (see 3.1.32).

Devices that do not fulfil the isolation function (for example a contactor switched off by a control circuit, or Power Drive System (PDS) with a safe torque off (STO) function in accordance with IEC 61800-5-2) may only be used for prevention of unexpected start-up during tasks such as:

- 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 (e.g. replacement of plug-in devices without disturbing existing wiring).

The selection of a device should take into account, for example, information derived from the risk assessment, intended use and foreseeable misuse of the device and the persons who operate them.

5.5 Devices for isolating electrical equipment

Devices shall be provided for isolating (disconnecting) the electrical equipment or part(s) of the electrical equipment to enable work to be carried out when it is de-energized and isolated. Such devices shall be:

- appropriate and convenient for their intended use;
- suitably placed;
- readily identifiable as to which part(s) or circuit(s) of the equipment is served. Where their function and purpose is not otherwise obvious (e.g. by their location) these devices shall be marked to indicate the extent of the equipment that they isolate.

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 crane-disconnector (see 5.3.6) may, in some cases, fulfil that function. However, where it is necessary to work on individual parts of the electrical equipment of a hoisting machine, or on one of the hoisting 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 hoisting machine, requiring separate isolation.

In addition to the crane-disconnector, 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 3.1.28) and relevant information is provided with the electrical equipment (see 17.2).

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), (e.g. 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 is used within an enclosed electrical operating area (e.g. withdrawable fuse-links, withdrawable links), other means of protection against reconnection (e.g. warning labels in accordance with 16.1) may be provided.

However, when a plug/socket combination in accordance with 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 by

- basic protection (see 6.2 and 6.4);
- fault protection (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 60364-4-41:2005. Where those recommended measures are not practicable, for example, due to the physical or operational conditions, other measures from IEC 60364-4-41:2005 may be used.

6.2 Basic protection

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 basic protection (e.g. by using barriers, by placing out of reach, using obstacles, using construction or installation techniques that prevent access) as defined in IEC 60364-4-41:2005 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 basic protection 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 provide protection against contact with live parts 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 contact with live parts 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 60364-4-41:2005.

NOTE 1 The use of a key or tool is intended to restrict access to skilled or instructed persons (see Clause 17).

All live parts (including those on the inside of doors) 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 (e.g. the crane-disconnector) 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

- 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 unauthorized closure of the disconnecting device;
- upon closing the door, the interlock is automatically restored;
- all live parts (including those on the inside of doors) 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 about the procedures for the defeat of the interlock is provided with the instructions for use of electrical equipment (see Clause 17);
- means are provided to restrict access to live parts behind doors that are not directly interlocked with the disconnecting means to skilled or instructed persons (see Clause 17).

All parts that are still live after switching off the disconnecting device(s) 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), except for:

- 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 crane-supply-switch and the crane-disconnector when they are 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. Where protection against 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 (e.g. pins), the discharge time to 60 V 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 (e.g. 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, for example a warning sign drawing attention to the hazard and stating the delay required shall be provided (see 16.2.3).

NOTE Frequency converters and DC bus supplies could have typically a longer discharge time than 5 s.

6.2.5 Protection by barriers

For protection by barriers, the requirements 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 or by obstacles, the requirements of IEC 60364-4-41 shall apply.

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

6.3 Fault protection

6.3.1 General

Fault protection 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 following measures, in accordance with 6.3.2 to 6.3.3, shall be applied:

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

NOTE 1 The risk of harmful physiological effects from touch voltages depends upon a number of factors. These include but are not limited to: value of touch voltage, duration of possible exposure, environmental factors, skin condition.

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 61439-1;
- supplementary or reinforced insulation in accordance with Clause 412 of IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017.

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 IEC 60364-4-41 apply.

6.3.3 Protection by automatic disconnection of supply

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 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 the limits specified in Annex A for TN and TT systems.

This measure necessitates co-ordination between:

- the type of supply systems, the supply source impedance and earthing system;
- the impedance values of the different elements of the line and of the associated fault current paths through the protective bonding circuit;
- the characteristics of the protective devices that detect insulation fault(s).

NOTE 1 Details of verification of conditions for protection by automatic disconnection of supply are provided in 18.2.

This protective measure comprises both

- protective bonding of exposed conductive parts (see 8.2.3);
- and one of following:
 - a) In TN systems, the following protective devices may be used:
 - overcurrent protective devices;
 - residual current protective devices (RCDs) and associated overcurrent protective device(s).

NOTE 2 The preventive maintenance can be enhanced by use of a residual current monitoring device, RCM, complying with IEC 62020-1.

- b) In TT systems, either:
 - RCDs and associated overcurrent protective device(s) 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; or
 - overcurrent protective devices may be used for fault protection provided a suitably low value of the fault loop impedance Z_S (see A.2.2.3) is permanently and reliably assured.

NOTE 3 The preventive maintenance can be enhanced by use of a residual current monitoring device, RCM, complying with IEC 62020-1.

- c) In IT systems, the relevant requirements of IEC 60364-4-41 shall be fulfilled. During an insulation fault an acoustic and optical signal shall be sustained. After annunciation, the acoustic signal may then be manually muted. This can require an agreement between the supplier and user regarding the provision of insulation monitoring devices and/or insulation fault location system(s).

NOTE 4 In large machines, the provision of an insulation fault location system in accordance with IEC 61557-9:2014 can facilitate maintenance.

Where automatic disconnection is provided in accordance with a), and disconnection within the time specified in A.1.1 cannot be assured, supplementary protective bonding shall be provided as necessary to meet the requirements of A.1.3.

Where a power drive system (PDS) is provided, fault protection shall be provided for those circuits of the PDS that are supplied by the converter. Where this protection is not provided within the converter, the necessary protection measures shall be in accordance with the converter manufacturer's instructions.

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 RMS 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 RMS 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 % RMS.

- 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:
 - 1) plugs shall not be able to enter socket-outlets of other voltage systems;
 - 2) 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 (e.g. a motor generator with winding providing equivalent isolation);
- an electrochemical source (e.g. a battery) or another source independent of a higher voltage circuit (e.g. 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 7 details the measures to be taken to protect equipment against the effects of

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

If one of these malfunctions causes the operation of a protective device resulting in the stopping of a motion drive motor, an automatic restart shall be prevented.

NOTE This requirement can be met, for example, by means of:

- a crane-switch which can only be switched on if all operator control devices are in the off position;
- operator control devices which automatically return to the off position.

Where only a part of a hoisting machine or a group of hoisting machines working together in a coordinated manner is affected by the operation of a protective device, such operation shall initiate appropriate control responses to ensure co-ordination (see also 9.3.4).

7.2 Overcurrent protection

7.2.1 General

Overcurrent protection shall be provided where the current in any 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 used are detailed in 7.2.10.

7.2.2 Supply conductors

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

The supplier of the electrical equipment shall state in the installation document the data necessary for conductor dimensioning (including the maximum cross-sectional area of the supply conductor that can be connected to the terminals of the electrical equipment) and for selecting the overcurrent protective device (see 7.2.10 and 17.2).

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 including also circuits which are supplying control circuit transformers.

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;
- DC power conductors bonded to exposed conductive parts of mobile machines.

Where the cross-sectional area of the neutral conductor is at least equal to, or equivalent to, that of the line conductors, it is not necessary to provide overcurrent detection for the neutral conductor nor a disconnecting device for that conductor. For a neutral conductor with a cross-sectional area smaller than that of the associated line conductors, the measures detailed in Clause 524 of IEC 60364-5-52:2009 shall apply.

In IT-systems, it is recommended that the neutral conductor is not used. However, where a neutral conductor is used, the measures detailed in 431.2.2 of IEC 60364-4-43:2008 shall apply.

7.2.4 Control circuits

Conductors of control circuits directly connected to the supply voltage shall be protected against overcurrent in accordance with 7.2.3.

Conductors of control circuits supplied by a transformer or DC supply shall be protected against overcurrent (see also 9.4.3.1):

- in control circuits connected to the protective bonding circuit, by inserting an overcurrent protective device into the switched conductor;
- in control circuits not connected to the protective bonding circuit:
 - a) where all control circuits of the equipment have the same current-carrying capacity, by inserting an overcurrent protective device into the switched conductor; or
 - b) where control circuits of the equipment have different current-carrying capacity, by inserting an overcurrent protective device into both switched and common conductors of each control circuit.

Exception: Where the supply unit provides current limiting below the current-carrying capacity of the conductors in a circuit and below the current rating of connected components, no separate overcurrent protective device is required.

7.2.5 Socket outlets and their associated conductors

Overcurrent protection shall be provided for the circuits feeding the general purpose socket outlets intended primarily for supplying power to maintenance equipment. Overcurrent protective devices shall be provided in the unearthed live conductors of each circuit feeding such socket outlets. See also 15.1.

7.2.6 Lighting circuits

All unearthed conductors of circuits supplying lighting shall be protected against the effects of short circuits by the provision of overcurrent devices separate from those protecting other circuits.

7.2.7 Transformers

Transformers shall be protected by an overcurrent protective device having a type and settings in accordance with the transformer manufacturer's instructions. Such protection shall (see also 7.2.10)

- avoid nuisance tripping due to transformer magnetizing inrush currents;
- avoid a winding temperature rise in excess of the permitted value for the insulation class of transformer when it is subjected to the effects of a short circuit at its secondary terminals.

7.2.8 Location of overcurrent protective devices

An overcurrent protective device shall be located at the point where a reduction in the cross-sectional area of the conductors or another change reduces the current-carrying capacity of the conductors, except where all the following conditions are satisfied.

- The current-carrying capacity of the conductors is at least equal to that of the load.
- The part of the conductor(s) between the point of reduction of the current-carrying capacity and the position of the overcurrent protective device is no longer than 3 m.
- The conductors are installed in such a manner as to reduce the possibility of a short circuit, for example, protected against mechanical damage by an enclosure or a duct, or by other suitable means.

7.2.9 Overcurrent protective devices

The rated short-circuit breaking capacity shall be at least equal to the prospective fault current at the point of installation. Where the short-circuit current to an overcurrent protective device can include additional currents other than from the supply (e.g. from motors, from power factor correction capacitors), those currents shall be taken into consideration.

A lower breaking capacity is permitted where another protective device (e.g. the overcurrent protective device for the supply conductors (see 7.2.2) having the necessary breaking capacity is installed on the supply side. In that case, the characteristics of the two devices shall be coordinated so that the let-through energy (I^2t) of the two devices in series does not exceed that which can be withstood without damage to the overcurrent protective device on the load side and to the conductors protected by that device (see Annex A of IEC 60947-2:2016).

NOTE The use of such a coordinated arrangement of overcurrent protective devices can result in the operation of both overcurrent protective devices.

Where fuses are provided as overcurrent protective devices, a type readily available in the country of use shall be selected, or arrangements shall be made for the supply of spare parts.

7.2.10 Rating and setting of overcurrent protective devices

The rated current of fuses or the setting current of other overcurrent protective devices shall be selected as low as possible but adequate for the anticipated overcurrents (e.g. during starting of motors or energizing of transformers). When selecting those protective devices, consideration shall be given to the protection of switching devices against damage due to overcurrents.

The rated current or setting of an overcurrent protective device for conductors is determined by the current-carrying capacity of the conductors to be protected in accordance with 12.4, Clause C.3 and the maximum allowable interrupting time t in accordance with Clause C.4, taking into account the needs of coordination with other electrical devices in the protected circuit.

In case of multi-motor drives, the overcurrent protection in the feeding system might not be able to protect a single branch cable in case of a short circuit failure. Additional protective measures or dimensioning of branch cables with respect to the maximum short-circuit current are required.

7.3 Protection of motors against overheating

7.3.1 General

Protection of motors against overheating shall be provided for each motor rated at more than 2 kW.

Exceptions: In applications where an automatic interruption of the motor operation is unacceptable (e.g. in load holding devices), the means of detection shall give a warning signal to which the operator can respond.

Protection of motors against overheating can be achieved by

- overload protection (7.3.2);

NOTE 1 Overload protective devices detect the time and current relationships (I^2t) in a circuit that are in excess of the rated full load of the circuit and initiate appropriate control responses.

- over-temperature protection (7.3.3); or

NOTE 2 Temperature detection devices sense over-temperature and initiate appropriate control responses.

- current-limiting protection.

Automatic restarting of any motor after the operation of protection against overheating shall be prevented where this can cause a hazardous situation or damage to the machine or to the work in progress.

7.3.2 Overload protection

Where overload protection is provided, detection of overload(s) shall be provided in each live conductor except for the neutral conductor. However, where the motor overload detection is not used for cable overload protection (see also Clause C.3), detection of overload may be omitted in one of the conductors. For motors having single-phase or DC power supplies, detection in only one unearthed live conductor is permitted.

Where overload protection is achieved by switching off, the switching device shall switch off all live conductors. The switching of the neutral conductor is not necessary for overload protection.

Where motors with special duty ratings are required to start or to brake frequently (e.g. motors for rapid traverse, locking, rapid reversal, plugging and inching), it can be difficult to provide overload protection with a time constant comparable with that of the winding to be protected. Protective devices designed to accommodate special duty motors or over-temperature protection (see 7.3.3) can be necessary.

For motors that cannot be overloaded (e.g. torque motors, motion drives that either are protected by mechanical overload protection devices or are adequately dimensioned), overload protection is not required.

7.3.3 Over-temperature protection

The provision of motors with over-temperature protection (in accordance with IEC 60034-11) is recommended in situations where the cooling can be impaired. Depending upon the type of motor, protection under stalled rotor or loss of phase conditions is not always ensured by over-temperature protection, and additional protection should then be provided.

Over-temperature protection is also recommended for motors that cannot be overloaded (e.g. torque motors, motion drives that are either protected by mechanical overload protection devices or are adequately dimensioned), where the possibility of over-temperature exists (e.g. due to reduced cooling).

NOTE Cooling can be impaired, for example, due to dusty environment and when motors with shaft-mounted fans are driven at low speeds.

7.4 Protection against abnormal temperature

Braking resistors or other equipment that are capable of attaining or causing abnormal temperatures (e.g. due to short-time rating or loss of cooling medium) and therefore can cause a hazardous situation shall be provided with suitable detection to initiate an appropriate control response.

7.5 Protection against the effects of supply interruption or voltage reduction and subsequent restoration

Where a supply interruption or a voltage reduction can cause a hazardous condition, such as damage to the hoisting machine, or to the load, undervoltage protection shall be provided (e.g. by switching off the hoisting machine and/or engaging mechanical brakes) at a predetermined voltage level.

NOTE Depending on the risk assessment, undervoltage protection can be omitted on a manually controlled hoisting machine.

Where the operation of the hoisting machine can allow for an interruption or a reduction of the voltage for a short time period, delayed undervoltage protection may be provided. The operation of the undervoltage device shall not impair the operation of any stopping control of the hoisting machine.

Upon restoration of the voltage or upon switching on the incoming supply, automatic or unexpected restarting of the hoisting machine shall be prevented where such a restart can cause a hazardous situation.

Where only a part of the hoisting machine or of the group of hoisting machines working together in a coordinated manner is affected by the voltage reduction or supply interruption, the undervoltage protection shall initiate appropriate control commands to ensure coordination.

7.6 Motor overspeed protection

Overspeed protection shall be provided where overspeeding can occur and could possibly cause a hazardous situation taking into account measures in accordance with 9.2.5.5. and 9.3.3. Overspeed protection shall initiate appropriate control responses and shall prevent automatic restarting.

The overspeed protection should operate in such a manner that the mechanical speed limit of the motor or its load is not exceeded.

NOTE 1 This protection can consist, for example, of a centrifugal switch, speed limit monitor, or speed monitoring built into the drive system.

NOTE 2 Inadmissible high speeds could occur, for example, in hoisting drives equipped with DC motors or with variable speed drives.

7.7 Additional earth fault/residual current protection

In addition to providing overcurrent protection for automatic disconnection as described in 6.3, earth fault/residual current protection can be provided to reduce damage to equipment due to earth fault currents less than the detection level of the overcurrent protection.

The setting of the devices shall be as low as possible consistent with correct operation of the equipment.

If fault currents with DC components are possible, an RCD of type B in accordance with IEC 60755:2017 can be required.

7.8 Phase sequence protection

Where an incorrect phase sequence of any supply voltage (including alternative power supply, e.g. generator in case of emergency) can cause a hazardous situation or damage to the hoisting machine, phase sequence protection shall be provided.

NOTE Conditions of use that can lead to an incorrect phase sequence include:

- a hoisting machine transferred from one supply to another;
- a mobile crane with a facility for connection to an external power supply.

A hoisting machine with provision of an electrical power supply for auxiliary devices (e.g. for repairs with auxiliary hoists) shall have a phase sequence protection device to ensure the correct motor rotation.

7.9 Protection against overvoltages due to lightning and to switching surges

Surge protective devices (SPDs) can be provided to protect against the effects of overvoltages due to lightning or to switching surges.

Where provided,

- SPDs for the suppression of overvoltages due to lightning shall be connected to the incoming terminals of the crane-supply-switch and/or crane-disconnector;
- SPDs for the suppression of overvoltages due to switching surges shall be connected as necessary for equipment requiring such protection.

NOTE 1 Information about the correct selection and installation of SPDs is given, for example, in IEC 60364-4-44, IEC 60364-5-53, IEC 61643-12, IEC 62305-1 and IEC 62305-4.

NOTE 2 Equipotential bonding of the machine, its electrical equipment and extraneous conductive parts to a common bonding network of the building/site can help mitigate electromagnetic interference, including the effects of lightning, on the equipment.

If the risk assessment requires, outdoor cranes shall be equipped with a lightning protection system including the following.

a) Air-termination systems

A separate air termination might not be necessary if the structure of the crane performs this function.

b) Down-conductor systems

The structure of the hoisting machine – with all hinged and other moving joints by-passed by a grounding conductor – can be used as a down conductor.

c) Earth-termination systems

The earth-termination may include grounding collectors to crane rails.

NOTE 1 Guidance for the risk assessment and for lightning protection systems is given in the IEC 62305 series.

NOTE 2 There can be national requirements for lightning protection.

7.10 Short-circuit current rating

The short-circuit current rating of the electrical equipment shall be determined. This can be done by the application of design rules or by calculation or by test.

NOTE The short-circuit current rating can be determined, for example, in accordance with IEC 61439-1, IEC 60909-0, IEC TR 60909-1, or IEC TR 61912-1.

8 Equipotential bonding

8.1 General

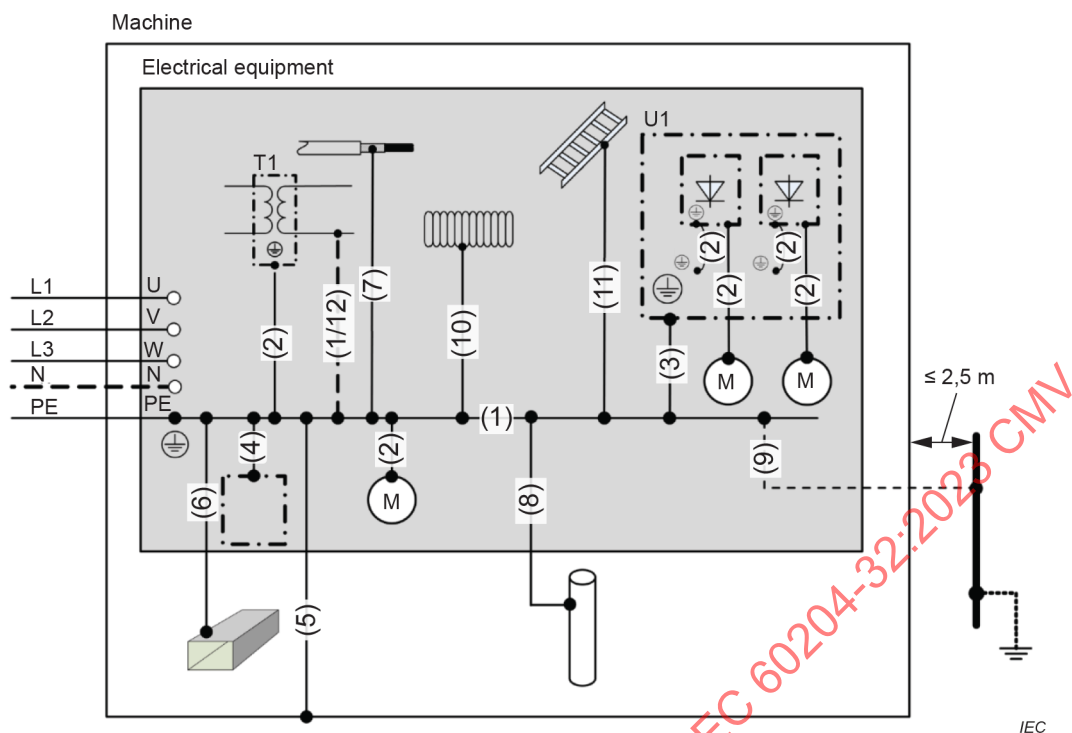
This Clause 8 provides requirements for protective bonding and functional bonding. Figure 6 illustrates those concepts.

Protective bonding is a basic provision for fault protection to enable protection of persons against electric shock (see 6.3.3 and 8.2).

The objective of functional bonding (see 8.3) is to reduce:

- the consequence of an insulation failure which could affect the operation of the hoisting machine;
- electrical disturbances to sensitive electrical equipment which could affect the operation of the hoisting machine;
- induced currents from lightning which could damage the electric equipment.

Functional bonding is achieved by connection to the protective bonding circuit, but, where the level of electrical disturbances on the protective bonding circuit is not sufficiently low for proper functioning of electrical equipment, it can be necessary to use separate conductors for protective and functional bonding (see Figure 6).



Protective bonding circuit:	
(1)	Interconnection of protective conductor(s) and the PE terminal
(2)	Connection of exposed conductive parts
(3)	Protective conductor connected to an electrical equipment mounting plate used as a protective conductor
(4)	Connection of conductive structural parts of the electrical equipment
(5)	Conductive structural parts of the machine
Parts connected to the protective bonding circuit which are not to be used as protective conductor:	
(6)	Metal ducts of flexible or rigid construction
(7)	Metallic cable sheaths or armouring
(8)	Metallic pipes containing flammable materials
(9)	Extraneous conductive parts, if earthed independently from the power supply of the machine and liable to introduce a potential, generally the earth potential, (see 17.2 d)), e.g.: – metallic pipes, – fences, – ladders, – handrails.
(10)	Flexible or pliable metal conduits
(11)	Protective bonding of support wires, cable trays and cable ladders
Connections to the protective bonding circuit for functional reasons:	
(12)	Functional bonding
Legend to reference designations:	
T1	Auxiliary transformer
U1	Mounting plate of electrical equipment

Figure 6 – Example of equipotential bonding for electrical equipment of a hoisting machine

8.2 Protective bonding circuit

8.2.1 General

The protective bonding circuit consists of the interconnection of:

- PE terminal(s) (see 5.2);
- the protective conductors (see 3.1.69) including sliding contacts where they are part of the circuit;
- the conductive structural parts and exposed conductive parts of the electrical equipment;
Exception: see 8.2.5
- those conductive structural parts of the hoisting machine used for protective bonding.

Exception: For mobile cranes, when the supply of electrical energy is self-contained, and when there is no external supply connected (e.g. when an on-board battery charger is not connected), there is no need to connect such equipment to an external protective conductor.

All parts of the protective bonding circuit shall be so designed that they are capable of withstanding the highest thermal and mechanical stresses that can be caused by earth-fault currents that could flow in that part of the protective bonding circuit.

If an IT distribution system is used, the hoisting machine structure shall be part of the protective bonding circuit and insulation monitoring shall be provided. See 6.3.3 c).

Conductive structural parts of equipment in accordance with 6.3.2.2 need not be connected to the protective bonding circuit. Extraneous conductive parts which form the structure of the hoisting machine need not be connected to the protective bonding circuit where all the equipment provided is in accordance with 6.3.2.2.

Exposed conductive parts of equipment in accordance with 6.3.2.3 shall not be connected to the protective bonding circuit.

8.2.2 Protective conductors

Protective conductors shall be identified in accordance with 13.2.2.

Copper conductors are preferred. Where a conductor material other than copper is used, its electrical resistance per unit length shall not exceed that of the allowable copper conductor, and such conductors shall be not less than 16 mm² in cross-sectional area for reasons of mechanical durability.

Metal enclosures or frames or mounting plates of electrical equipment, connected to the protective bonding circuit, may be used as protective conductors if they satisfy the following three requirements:

- their electrical continuity shall be assured by construction or by suitable connection so as to ensure protection against mechanical, chemical or electrochemical deterioration;
- they comply with the requirements of 543.1 of IEC 60364-5-54:2011;
- they shall permit the connection of other protective conductors at every predetermined tap-off point.

The cross-sectional area of protective conductors shall either be calculated in accordance with 543.1.2 of IEC 60364-5-54:2011 or selected in accordance with Table 1 (see 5.2). See also 8.2.6 and 17.2 d) of this document.

Each protective conductor shall:

- be part of a multicore cable; or
- be in a common enclosure with the line conductor; or
- have a cross-sectional area of at least
 - 2,5 mm² Cu or 16 mm² Al if protection against mechanical damage is provided,
 - 4 mm² Cu or 16 mm² Al if protection against mechanical damage is not provided.

NOTE 1 The use of steel for a protective conductor is not excluded.

A protective conductor not forming part of a cable is considered to be mechanically protected if it is installed in a conduit, trunking or protected in a similar way.

The following parts of the machine and its electrical equipment shall be connected to the protective bonding circuit but shall not be used as protective conductors:

- metal ducts of flexible or rigid construction;
- metallic cable sheaths or armouring;
- metallic pipes containing flammable materials such as gases, liquids, powder.
- flexible or pliable metal conduits;
- conductive structural parts of the hoisting machine;
- flexible metal parts, support wires, cable trays and cable ladders.

NOTE 2 Information on cathodic protection is provided in 542.2.5 and 542.2.6 of IEC 60364-5-54:2011.

8.2.3 Continuity of the protective bonding circuit

Where a part is removed for any reason (e.g. routine maintenance), the protective bonding circuit for the remaining parts shall not be interrupted.

Connection and bonding points shall be so designed that their current-carrying capacity is not impaired by mechanical, chemical, or electrochemical influences. Where enclosures and conductors of aluminium or aluminium alloys are used, particular consideration should be given to the possibility of electrolytic corrosion.

Where the electrical equipment is mounted on lids, doors, or cover plates, continuity of the protective bonding circuit shall be ensured and a protective conductor (see 8.2.2) is recommended. Otherwise, fastenings, hinges or sliding contacts designed to have a low resistance shall be used (see 18.2.2, Test 1).

The continuity of the protective conductor in cables that are exposed to the risk of damage (e.g. flexible trailing cables) shall be ensured by appropriate measures (e.g. monitoring).

For requirements for the continuity of the protective conductor using conductor wires, conductor bars and slip-ring assemblies, see 12.7.2.

Rails of hoisting machines may be connected to the protective bonding circuit. However, they shall not replace the protective conductor (e.g. cable, conductor wire or conductor bar) from the supply source to the hoisting machine.

The electrical equipment of hoisting machines intended to be used at different sites (transportable hoisting machines) shall conform to the requirements of this document for all expected supply earthing systems. When used with IT or TT systems, the protective bonding circuit of the hoisting machine shall be connected to the earthing system of the site.

8.2.4 Exclusion of switching devices from the protective bonding circuit

The protective bonding circuit shall not incorporate a switching device or an overcurrent protective device (e.g. switch, fuse) or other means of interruption.

Exceptions:

- Links for test or measurement purposes that cannot be opened without the use of a tool and that are located in an enclosed electrical operating area.
- Where the continuity of the protective bonding circuit can be interrupted by means of removable current collectors or plug/socket combinations, the protective bonding circuit shall be interrupted by a first-make last-break contact. This also applies to removable or withdrawable plug-in units (see also 13.4.5).

8.2.5 Parts that need not be connected to the protective bonding circuit

It is not necessary to connect exposed conductive parts to the protective bonding circuit where those parts are mounted so that they do not constitute a hazard because

- they cannot be touched on large surfaces or grasped with the hand and they are small in size (less than approximately 50 mm × 50 mm); or
- they are located so that either contact with live parts, or an insulation failure, is unlikely.

This applies to small parts such as screws, rivets, and nameplates, and to parts inside an enclosure, irrespective of their size (e.g. electromagnets of contactors or relays and mechanical parts of devices).

NOTE Further information can be found in 410.3.9 of IEC 60364-4-41:2005.

8.2.6 Protective conductor connecting points

All protective conductors shall be terminated in accordance with 13.1.1. The protective conductor connecting points shall have no other function and shall not be used, for example, to attach or connect appliances or parts.

Each protective conductor connecting point shall be marked or labelled as such using the symbol IEC 60417-5019 (2006-08), as illustrated in Figure 7, or with the letters PE, the graphical symbol being preferred, or by use of the bicolour combination GREEN-AND-YELLOW, or by any combination of these.

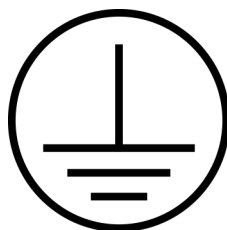


Figure 7 – Symbol IEC 60417-5019: Protective earth

8.2.7 Mobile hoisting machines

On mobile hoisting machines with on-board power supplies, the protective conductors, the conductive structural parts of the electrical equipment, and those extraneous conductive parts which form the structure of the hoisting machine shall all be connected to a protective bonding terminal to provide protection against electric shock. When this mobile hoisting machine with an on-board power supply is also capable of being connected to an external incoming supply, the protective bonding terminal shall be the connection point for the external protective conductor.

8.2.8 Additional requirements for electrical equipment having earth leakage currents higher than 10 mA AC or DC

NOTE 1 Earth leakage current is defined as “current flowing from the live parts of an installation to earth, in the absence of an insulation fault” (IEV 442-01-24). This current can have a capacitive component including that resulting from the deliberate use of capacitors.

NOTE 2 Most adjustable speed electrical power drive systems that conform to relevant parts of IEC 61800 will have an earth leakage current greater than 3,5 mA AC. A touch current measurement method is specified as a type test in IEC 61800-5-1 to determine the earth leakage current of an adjustable speed electrical power drive system.

Where electrical equipment has an earth leakage current (e.g. adjustable speed electrical power drive systems and information technology equipment) that is greater than 10 mA AC or DC in any incoming supply, one or more of the following conditions for the associated protective bonding circuit shall be satisfied.

- a) The protective conductor shall be part of the power supply cable or an enclosed busbar system and shall have a cross-sectional area of at least 1,5 mm² Cu through its total run.
- b) The protective conductor shall have a cross-sectional area of at least 10 mm² Cu or 16 mm² Al, through its total run.
- c) Where the protective conductor has a cross-sectional area of less than 10 mm² Cu or 16 mm² Al, a second protective conductor of at least the same cross-sectional area is provided up to a point where the protective conductor has a cross-sectional area not less than 10 mm² Cu or 16 mm² Al. This can require that the electrical equipment has a separate terminal for a second protective conductor.
- d) The supply is automatically disconnected in case of loss of continuity of the protective conductor.

To prevent difficulties associated with electromagnetic disturbances, 4.4.2 also applies to the installation of duplicate protective conductors.

A statement shall be given in the instructions for installation that the equipment shall be installed as described in this 8.2.8.

NOTE 3 A warning label can also be provided adjacent to the PE terminal to state that the protective conductor current exceeds 10 mA.

8.3 Functional bonding

Protection against maloperation as a result of insulation failures can be achieved by connecting to a common conductor in accordance with 9.4.3.1.

For recommendations regarding functional bonding to avoid maloperation due to electromagnetic disturbances, see 4.4.2 and Annex G.

Functional bonding connecting points should be marked or labelled as such using the symbol IEC 60417-5020 (2002-10) (see Figure 4).

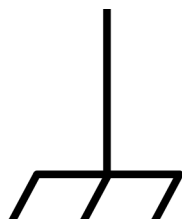


Figure 8 – Symbol IEC 60417-5020: Frame or chassis

8.4 Measures to restrict the effects of high leakage current

The effects of high leakage current can be restricted to the equipment having high leakage current by connection of that equipment to a dedicated supply transformer having separate windings. The protective bonding circuit shall be connected to exposed conductive parts of the equipment and, in addition, to the secondary winding of the transformer. The protective conductor(s) between the equipment and the secondary winding of the transformer shall conform to one or more of the arrangements described in 8.2.8.

9 Control circuits and control functions

9.1 Control circuits

9.1.1 General

Subclause 9.1 is not applicable for hand-held direct-control devices (see 3.1.45).

9.1.2 Control circuit supply

Where control circuits are supplied from an AC source, transformers or switch mode power supply units having separate windings shall be used to separate the power supply from the control supply, for example:

- transformers having separate windings in accordance with IEC 61558-2-2;
- switch mode power supply units in accordance with IEC 61558-2-16 fitted with transformers having separate windings;
- low voltage power supplies in accordance with IEC 61204-7 fitted with transformers having separate windings.

Where several transformers are used, it is recommended that the windings of those transformers be connected in such a manner that the secondary voltages are in phase.

Where DC control circuits derived from an AC supply are connected to the protective bonding circuit (see 8.2.1), they shall be supplied from a separate winding of the AC control circuit transformer or by another control circuit transformer.

NOTE Switch-mode units fitted with transformers having separate windings in accordance with IEC 61558-2-17 conform to this requirement.

Exception: Transformers or switch mode power supply units fitted with transformers are not mandatory for hoisting machines with a single motor starter and/or a maximum of two control devices (for example, interlock device, start/stop control station).

9.1.3 Control circuit voltages

The nominal value of the control voltage shall be consistent with the correct operation of the control circuit. The nominal voltage of AC control circuits should preferably not exceed

- 230 V for circuits with 50 Hz nominal frequency,
- 277 V for circuits with 60 Hz nominal frequency.

The nominal voltage of DC control circuits should preferably not exceed 220 V.

9.1.4 Protection

Control circuits shall be provided with overcurrent protection in accordance with 7.2.4 and 7.2.10.

9.2 Control functions

9.2.1 General

Subclause 9.2 does not specify requirements for the equipment used to implement control functions. Examples of such requirements are given in Clause 10.

9.2.2 Categories of stop functions

There are three categories of stops as follows:

- stop category 0: stopping by immediate removal of power to the hoisting machine actuators (i.e. an uncontrolled stop – see 3.1.85);
- stop category 1: a controlled stop (see 3.1.17) with power available to the hoisting machine actuators to achieve the stop and then removal of power when the stop is achieved;
- stop category 2: a controlled stop with power remaining available to the hoisting machine actuators.

NOTE For removal of power, it can be sufficient to remove the power needed to generate a torque or force. This can be achieved by disconnecting, switching off, or by electronic means (e.g. a PDS in accordance with the IEC 61800 series), etc.

9.2.3 Operating modes

Each hoisting machine can have one or more operating modes (for example manual mode, automatic mode, setting mode, maintenance mode) determined by the type of hoisting machine and its application.

Where machinery has been designed and constructed to allow its use in several control or operating modes requiring different protective measures and having a different impact on safety, it shall be fitted with a mode selector which can be locked in each position (for example key operated switch or electrical interlocking). Each position of the selector shall be clearly identifiable and shall correspond to a single operating or control mode.

The selector may be replaced by another selection method which restricts the use of certain functions of the machinery to certain categories of operator (for example access code).

Mode selection by itself shall not initiate hoisting machine operation. A separate actuation of the start control shall be required.

For each specific operating mode, the relevant safety functions and/or protective measures shall be implemented.

Indication of the selected operating mode shall be provided (e.g. the position of a mode selector, the provision of an indicating light, a visual display indication).

9.2.4 Suspension of safeguarding

Where it is necessary to provide a means of suspending a particular safety function or protective measure during setting, testing and maintenance activities, such means shall be designed with due consideration of foreseeable misuse (see 5.4 c) of ISO 12100:2010).

During actual suspension of the safety function or protective measure, protection shall be ensured by

- disabling all other operating (control) modes; and
- other relevant means (see ISO 12100:2010), which can include, for example, one or more of the following:
 - initiation of operation by a hold-to-run device or by a similar control device;
 - a portable control station with an emergency stop device and, where appropriate, an enabling device. Where a portable control station is in use, initiation of motion shall only be possible from that control station;
 - a cableless control station with a device to initiate stop functions in accordance with 9.2.7.3 and, where appropriate, an enabling device. Where a cableless control station is in use, initiation of motion shall only be possible from that control station;
 - limitation of the speed or the power of motion;
 - limitation of the range of motion.

Additional requirements and limitations for suspension of particular safety functions may be defined in the specific product standards.

For example, the suspension of overload protection may be prohibited even during setting, testing and maintenance activities in case there is a stability problem with the particular hoisting machine.

9.2.5 Operation

9.2.5.1 General

Safety functions and/or protective measures (for example interlocks (see 9.3)) shall be provided where required to reduce the possibility of hazardous situations.

Measures shall be taken to prevent movement of the hoisting machine in an unintended or unexpected manner after any stopping of the hoisting machine (e.g. due to locked-off condition, power supply fault, battery replacement, lost signal condition with cableless control).

Manually controlled hoisting machines shall use either hold-to-run controls or two-position enabling devices (see 10.9) for operation; this requirement does not apply to cabin controlled hoisting machines with over-travel limiting devices where no hazardous condition can occur.

On a hoisting machine with more than one operator control station for the same motion drive, (e.g. cabin control and floor control), only one operator control station shall be enabled at any given time. For emergency stop, see 9.2.5.4.2 and 10.7. Means shall be provided to indicate the operational status of the operator control station.

9.2.5.2 Start

Start functions shall operate by energizing the relevant circuit.

The start of an operation (e.g. a motion) shall be possible only when all of the relevant safety functions and/or protective measures are in place and are operational except for conditions, as described in 9.2.4.

On those hoisting machines where safety functions and/or protective measures cannot be applied for certain operations (e.g. a particular motion), manual control of such operations shall be by hold-to-run controls, together with enabling devices, as appropriate.

The provision of acoustic and/or visual warning signals before starting machine operation which can result in hazardous situation shall be considered during the risk assessment. Where the risk assessment determines that either or both are required the emission level of these warning signals shall be suitable for the intended environment.

Suitable interlocks shall be provided to secure correct sequential starting.

In the case of hoisting machines which require the use of more than one control station to initiate a start, each of these control stations shall have a separate manually actuated start control device. The conditions to initiate a start shall be:

- all required conditions for hoisting machine operation shall be met; and
- all start control devices shall be in the released (off) position; then
- all start control devices shall be actuated concurrently (see 3.1.10).

9.2.5.3 Stop

Stop category 0 and/or stop category 1 and/or stop category 2 stop functions shall be provided as indicated by the risk assessment and the functional requirements of the hoisting machine (see 4.1, 9.4.1. and 9.4.4).

NOTE The supply disconnecting and switching devices (see 5.3) when operated achieve a stop category 0.

Stop functions shall override related start functions (see 9.2.5.2).

Where required, facilities to connect protective devices and interlocks shall be provided. If such a protective device or interlock causes a stop of the hoisting machine, it may be necessary for that condition to be signalled to the logic of the control system. The reset of the stop function shall not initiate any hazardous situation.

For movements that can be affected by gravity or other external forces (e.g. wind force), keeping the motion at stop should not be accomplished by the drive system but be secured by means not depending on power supply (e.g. by a mechanical brake). See also 9.3.5, 9.4.3.2 and 14.7.

9.2.5.4 Emergency operations (emergency stop, emergency switching-off)

9.2.5.4.1 General requirements

This document specifies the requirements for the emergency stop and the emergency switching-off functions of the emergency operations listed in Annex E, both of which are, in this document, initiated by a single human action.

Emergency stop and emergency switching-off are complementary protective measures that are not primary means of risk reduction for hazards (e.g. crushing, impact, electric shock or burn) at a hoisting machine (see ISO 12100:2010).

Once active operation of an emergency stop (see 10.7) or emergency switching-off (see 10.8) actuator has ceased following a command, the effect of this command shall be sustained until it is reset. This reset shall be possible only by a manual action at that location where the command has been initiated. The reset of the command shall not restart the hoisting machine but only permit restarting.

It shall not be possible to restart the hoisting machine until all emergency stop commands have been reset. It shall not be possible to reenergize the hoisting machine until all emergency switching-off commands have been reset.

9.2.5.4.2 Emergency stop

Principles for the design of emergency stop equipment, including functional aspects, are given in ISO 13850:2015.

Hoisting machines shall have an emergency stop function, which shall at least stop the motion drives and other hoisting machine actuators that can cause hazardous condition(s). The emergency stop shall function either as a stop category 0 or as a stop category 1 (see 9.2.2). The choice of the stop category of the emergency stop depends on the results of a risk assessment of the hoisting machine.

Exception: In some cases, to avoid creating additional risks, it can be necessary to perform a controlled stop and maintain the power to machine actuators even after stopping is achieved. The stopped condition shall be monitored and upon detection of failure of the stopped condition, power shall be removed without creating a hazardous situation.

In addition to the requirements for stop (see 9.2.5.3), the emergency stop function has the following requirements.

- It shall override all other functions and operations in all modes.
- It shall stop the hazardous motion as quickly as practicable without creating other hazards.
- Reset shall not initiate a restart.

The emergency stop function may be performed by one or more of the switching devices shown in Figure 3 (i.e. switchgear for drives, crane-switch or crane-supply-switch).

9.2.5.4.3 Emergency switching-off

The functional aspects of emergency switching-off are given in 536.4 of IEC 60364-5-53:2019.

Emergency switching-off should be provided where

- basic protection (for example with conductor wires, conductor bars, slip-ring assemblies, controlgear in electrical operating areas) is achieved only by placing out of reach or by obstacles (see 6.2.6); or
- there is the possibility of other hazards or damage caused by electricity.

Emergency switching-off is accomplished by switching off the relevant incoming supply by electromechanical switching devices (e.g. by the crane-supply-switch), effecting a stop category 0 of hoisting machine actuators connected to this incoming supply. When a hoisting machine cannot tolerate this stop category 0 stop, it may be necessary to provide other measures, for example, by basic protection, so that emergency switching-off is not necessary (e.g. load-holding devices like magnets and vacuum lifters may require continuous power supply).

9.2.5.5 Monitoring of command actions

Movement or action of a hoisting machine or part of a hoisting machine that can result in a hazardous situation shall be monitored. On manually controlled hoisting machines, operators can provide some of this monitoring. Conditions that cannot reasonably be expected to be monitored by the operator will require means which may include over-travel limiters, motor over-speed detection, mechanical overload detection or anti-collision devices.

9.2.6 Other control functions

9.2.6.1 Hold-to-run controls

Hold-to-run controls shall require continuous actuation of the control device(s) to achieve operation.

NOTE Hold-to-run control can be accomplished, for example, by two-hand control devices.

9.2.6.2 Two-hand control

Three types of two-hand control are defined in ISO 13851, the selection of which is determined by the risk assessment.

9.2.6.3 Enabling control

Enabling control (see also 10.9) is a manually activated control function interlock that,

- a) when activated allows a hoisting machine operation to be initiated by a separate start control; and
- b) when de-activated
 - 1) initiates a stop function, and
 - 2) prevents initiation of hoisting machine operation.

Enabling control shall be so arranged as to minimize the possibility of defeating, for example, by requiring the de-activation of the enabling control device before hoisting machine operation may be reinitiated. It should not be possible to defeat the enabling function by simple means.

The selection of the type of the enabling control device shall be made according to a risk assessment.

NOTE A three position type control device can have advantage in case of cramp or panic.

9.2.6.4 Combined start and stop controls

Push-buttons and similar control devices that, when operated, alternately initiate and stop motion shall only be provided for functions which cannot result in a hazardous situation.

9.2.7 Cableless control system (CCS)

9.2.7.1 General requirements

This 9.2.7 deals with the functional requirements and interfacing of control systems employing cableless techniques for transmitting commands and signals between a hoisting machine control system and operator control station(s) (see Clause 10, in particular see 10.1.5).

Transmission reliability requirements can be necessary for safety functions of a CCS that rely on data transmission (for example, safety-related active stop, motion commands).

Further requirements for cableless control systems are given in IEC 62745:2017.

9.2.7.2 Stop

Requirements for stop functions are given in 4.7 of IEC 62745:2017.

The response time of the stop function shall not exceed 550 ms after a stop command has been initiated.

A cableless control system (CCS) shall automatically initiate the stopping of the hoisting machine by de-energizing the crane-switch according to IEC 62745:2017, 4.7.3.5 (automatic stop function ATS).

Exceptions:

For those applications where 550 ms is too short, this value may be extended up to a maximum of 2 s. The foreseen usage of the hoisting machine shall be evaluated to ensure that additional risks do not result from this extension of the time value. If the CCS is not able to regain the control of the hoisting machine, the de-energizing of the crane-switch may be delayed for a maximum of 5 min provided that the initiation of stopping is assured by monitoring the state of the control system.

Every CCS shall be equipped at least with a GSS (general safe stop) in accordance with IEC 62745:2017.

9.2.7.3 Use of multiple operator control stations

NOTE This 9.2.7.3 does not consider switching between hardwired and cableless control stations.

See 4.12 and 4.13 of IEC 62745:2017.

9.3 Protective interlocks

9.3.1 General

Subclauses 9.3.2 to 9.3.6 do not specify requirements for the equipment used to implement protective interlock control functions. Examples of such requirements are given in Clause 10.

9.3.2 Reclosing or resetting of an interlocking safeguard

The reclosing or resetting of an interlocking safeguard shall not initiate hazardous hoisting machine motion or other operation.

NOTE Requirements for interlocking guards with a start function (control guards) are given in 6.3.3.2.5 of ISO 12100:2010.

9.3.3 Exceeding operating limits

Where an operating limit (e.g. load, position, speed, pressure) can be exceeded leading to a hazardous situation, means (e.g. a position sensor or a limit switch) shall be provided to detect when a predetermined limit(s) is exceeded and initiate an appropriate control action determined by the risk assessment of the hoisting machine.

When a position limiting device has initiated the stopping function, a motion shall be possible only in the opposite direction.

9.3.4 Operation of auxiliary functions

The correct operation of auxiliary functions shall be checked by appropriate devices (e.g. pressure sensors).

Where the non-operation of a motor or device for an auxiliary function (e.g. lubrication, supply of coolant) can cause a hazardous condition or damage to the hoisting machine or to the load, appropriate interlocking shall be provided.

9.3.5 Interlocks between different operations and for contrary motions

All contactors, relays, and other control devices that control elements of the hoisting machine and that can cause a hazardous condition when actuated at the same time (e.g. those which initiate contrary motion), shall be interlocked against incorrect operation.

Reversing contactors (e.g. those controlling the direction of rotation of a motor) shall be interlocked in such a way that in normal service no short circuit can occur when switching.

Where, for safety or for continuous operation, certain functions on the hoisting machine are required to be interrelated, proper coordination shall be ensured by suitable interlocks. For a group of hoisting machines working together in a coordinated manner and having more than one controller, provision shall be made to coordinate the operations of the controllers as necessary.

Where a failure of a mechanical brake actuator can result in the brake being applied when the associated hoisting machine actuator is energized, and a hazardous condition can result, interlocks shall be provided to switch off the hoisting machine actuator.

When the hoisting machine actuator is not energized, and a hazardous condition can result if the mechanical brakes are released, interlocks shall be provided to disable release of the mechanical brakes.

9.3.6 Reverse current braking

Where reverse current braking is used on a motor, measures shall be taken to prevent the motor starting in the opposite direction at the end of braking where that reversal can cause a hazardous condition or damage to the hoisting machine or to the load. Devices operating exclusively as a function of time shall not be used for this purpose.

This requirement is only applicable on hoisting machines in automatic operation.

9.4 Control functions in the event of failure

9.4.1 General requirements

Where failures or disturbances in the electrical equipment can cause a hazardous situation or damage to the hoisting machine or to the load, measures shall be taken to minimize the probability of the occurrence of such failures or disturbances. The required measures and the extent to which they are implemented, either individually or in combination, depend on the level of risk associated with the respective application (see 4.1).

Examples of such measures that can be appropriate include but are not limited to:

- protective interlocking of the electrical circuit;
- use of proven circuit techniques and components (see 9.4.2.2);
- provision of partial or complete redundancy (see 9.4.2.3) or diversity (see 9.4.2.4);
- provision for functional tests (see 9.4.2.5).

The electrical control system(s) shall have an appropriate performance that has been determined from the risk assessment of the machine.

The requirements for safety-related control functions of IEC 62061 and/or ISO 13849-1, ISO 13849-2 shall apply.

For non safety-related control functions basic safety principles of this document are applicable and adequate.

Where memory retention is achieved, for example, by battery power, measures shall be taken to prevent hazardous situations arising from failure, undervoltage or removal of the battery.

Means shall be provided to prevent unauthorized or inadvertent memory alteration by, for example, requiring the use of a key, access code or tool.

9.4.2 Measures to minimize risk in the event of failure

9.4.2.1 General

Measures to minimize risk in the event of failure include but are not limited to:

- use of proven circuit techniques and components;
- provisions of partial or complete redundancy;
- provision of diversity;
- provision for functional tests.

9.4.2.2 Use of proven circuit techniques and components

These measures include, but are not limited to:

- bonding of control circuits to the protective bonding circuit for functional purposes (see 9.4.3.1 and Figure 4);
- connection of control devices in accordance with 9.4.3.1;
- stopping by de-energizing (see 9.2.2);
- switching of all control circuit conductors to the device being controlled (see 9.4.3.1);
- switching devices having direct opening action (see IEC 60947-5-1);
- monitoring by
 - use of mechanically linked contacts (see IEC 60947-5-1:2016),
 - use of mirror contacts (see IEC 60947-4-1:2018);
- circuit design to reduce the possibility of failures causing undesirable operations;
- using components (e.g. programmable electronic control systems) designed to reach a suitable specified performance level (see ISO 13849-1) or safety integrity level (see IEC 62061).

9.4.2.3 Provisions of partial or complete redundancy

By providing partial or complete redundancy, it is possible to minimize the probability that one single failure in the electrical circuit can result in a hazardous situation. Redundancy can be effective in normal operation (on-line redundancy) or designed as special circuits that take over the protective function (off-line redundancy) only where the operating function fails.

Where off-line redundancy which is not active during normal operation is provided, suitable measures shall be taken to ensure that those control circuits are available when required.

9.4.2.4 Provision of diversity

The use of control circuits having different principles of operation or using different types of components or devices can reduce the probability of hazards resulting from faults and/or failures. Examples include:

- the use of combination of normally open and normally closed contacts operated by interlocking guards;
- the use of different types of control devices in the circuit(s);
- the combination of electromechanical and electronic equipment in redundant configurations.

The combination of electrical and non-electrical systems (e.g. mechanical, hydraulic, pneumatic) can perform the redundant function and provide the diversity.

9.4.2.5 Provision for functional tests

Functional tests may be carried out automatically by the control system, or manually by inspection or tests at start-up and at predetermined intervals, or a combination as appropriate (see also 17.2 and 18.6).

9.4.3 Protection against malfunction of control circuits

9.4.3.1 Insulation faults

9.4.3.1.1 General

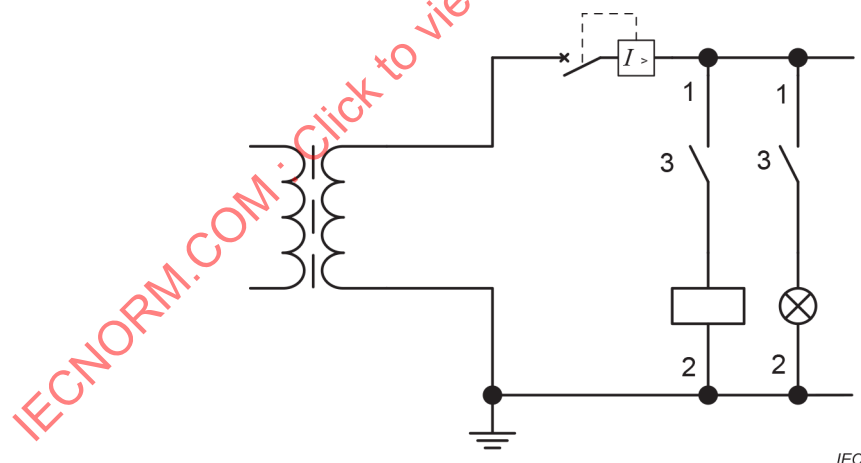
Measures shall be provided to reduce the probability that insulation faults on any control circuit can cause malfunction such as unintentional starting, potentially hazardous motions, or prevent stopping of the machine.

The measures to meet the requirements include but are not limited to the following methods:

- method a) Earthed control circuits fed by transformers;
- method b) Non-earthed control circuits fed by transformers;
- method c) Control circuits fed by transformer with an earthed centre-tap winding;
- method d) Control circuits not fed by a transformer.

9.4.3.1.2 Method a) Earthed control circuits fed by transformers

The common conductor shall be connected to the protective bonding circuit at the point of supply. All contacts, solid state elements, etc., which are intended to operate an electromagnetic or other device (for example, a relay, indicator light) are to be inserted between the switched conductor of the control circuit supply and one terminal of the coil or device. The other terminal of the coil or device is connected directly to the common conductor of the control circuit supply without any switching elements (see Figure 9).



- 1 Switched conductors
- 2 Common conductors
- 3 Control switches

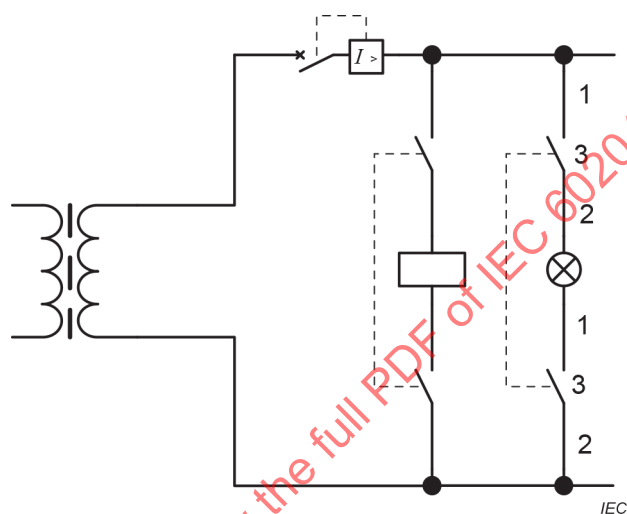
Figure 9 – Method a) Earthed control circuit fed by a transformer

NOTE Method a) can be used also for DC control circuits. In this case the transformer shown in Figure 9 is substituted by a DC power supply unit.

Exception: Contacts of protective devices may be connected between the common conductor and the coils, provided that the connection is very short (for example in the same enclosure) so that an earth fault is unlikely (for example overload relays directly fitted to contactors).

Control circuits fed from a control transformer that is not connected to the protective bonding circuit shall either:

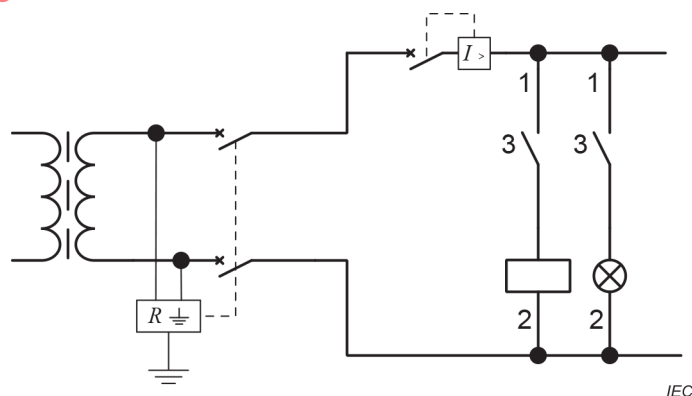
- b1) have 2-pole control switches that operate on both conductors, see Figure 10; or
- b2) be provided with a device, for example an insulation monitoring device, that interrupts the circuit automatically in the event of an earth fault, see Figure 11; or
- b3) where an interruption as per item b2) above would increase the risk, for example when continued operation is required during the first fault to earth, it can be sufficient to provide an insulation monitoring device (e.g. in accordance with IEC 61557-8:2014) that will initiate an acoustic and optical signal at the machine, see Figure 12. Requirements for the procedure to be performed by the machine user in response to this alarm shall be described in the information for use.



- 1 Switched conductors
- 2 Common conductors
- 3 Control switches

Figure 10 – Method b1) Non-earthed control circuit fed by transformer

NOTE 1 Method b1) can be used also for DC control circuits. In this case the transformer shown in Figure 10 is substituted by a DC power supply.

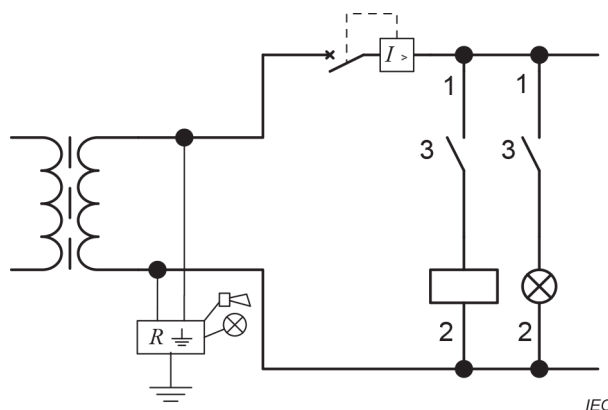


- 1 Switched conductors
- 2 Common conductors
- 3 Control switches

Figure 11 – Method b2) Non-earthed control circuit fed by transformer

NOTE 2 Method b2) can be used also for DC control circuits. In this case the transformer shown in Figure 11 is substituted by a DC power supply.

NOTE 3 Figure 11 does not show the overcurrent protective devices in the measurement circuits for protection of the insulation monitoring device.



- 1 Switched conductors
- 2 Common conductors
- 3 Control switches

Figure 12 – Method b3) Non-earthed control circuit fed by transformer

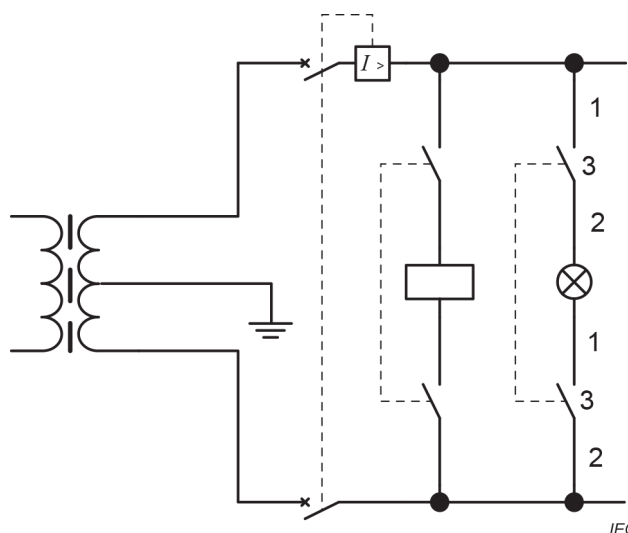
NOTE 4 Method b3) can be used also for DC control circuits. In this case the transformer shown in Figure 12 is substituted by a DC power supply. When a transformer and rectifier combination is used, the insulation monitoring device is connected to the protective bonding circuit in the DC part of the control circuit, so after the rectifier.

NOTE 5 Figure 12 does not show the overcurrent protective devices in the measurement circuits for protection of the insulation monitoring device.

9.4.3.1.4 Method c) Control circuits fed by transformer with an earthed centre-tap winding

Control circuits fed from a control transformer with its centre-tap winding connected to the protective bonding circuit shall have overcurrent protective devices that break both the conductors.

The control switches shall be 2-pole types that operate on both conductors.



- 1 Switched conductors
- 2 Common conductors
- 3 Control switches

Figure 13 – Method c) Control circuits fed by transformer with an earthed centre-tap winding

9.4.3.1.5 Method d) Control circuits not fed by a transformer

Control circuits that are not fed by a control transformer or switch mode power supply units fitted with transformers having separate windings in accordance with IEC 61558-2-16 are only allowed for machines with a maximum of one motor starter and/or maximum of two control devices, in accordance with 9.1.2.

Depending on the earthing of the supply system the possible cases are:

- d1) directly connected to an earthed supply system (TN- or TT-system) and:
 - d1a) being powered between a line conductor and the neutral conductor, see Figure 14; or
 - d1b) being powered between two line conductors, see Figure 15; or
- d2) directly connected to a supply system that is not earthed or is earthed through a high impedance (IT-system) and:
 - d2a) being powered between a line conductor and the neutral conductor, see Figure 16; or
 - d2b) being powered between two line conductors, see Figure 17.

Method d1b) requires multi-pole control switches that switch all live conductors in order to avoid an unintentional start in case of an earth fault in the control circuit.

Method d2) requires that a device shall be provided that interrupts the circuit automatically in the event of an earth fault.

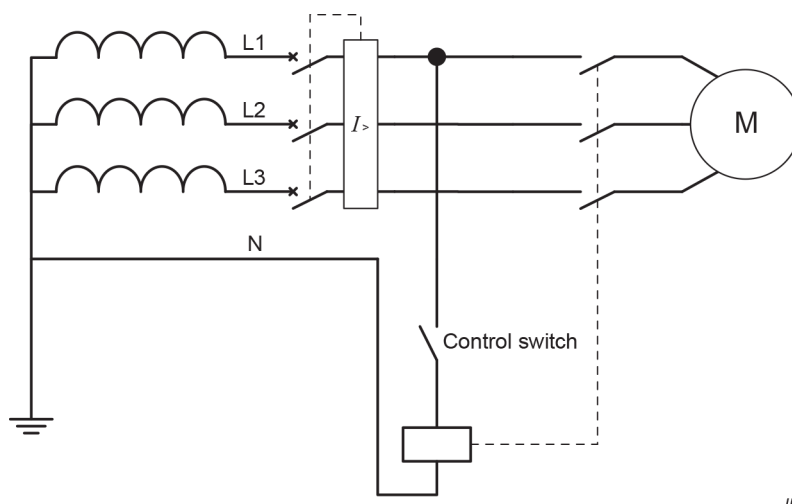


Figure 14 – Method d1a) Control circuit without transformer connected between a phase and the neutral of an earthed supply system

NOTE 1 Figure 14 shows the case where the supply system is a TN system. The control circuit is the same in the case of a TT system.

NOTE 2 Figure 14 does not show any protective devices for the power circuit and control circuit, provisions for which are stated in 6.3 and 7.2.

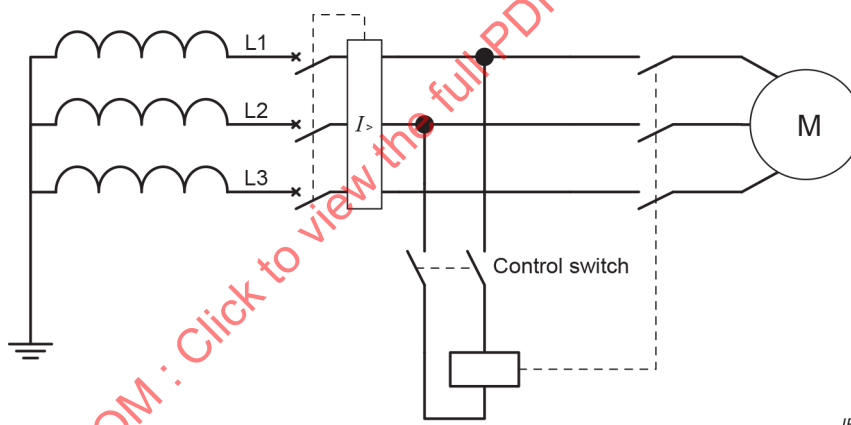


Figure 15 – Method d1b) control circuit without transformer connected between two phases of an earthed supply system

NOTE 3 Figure 15 shows the case where the supply system is a TN system. The control circuit is the same in case of a TT system.

NOTE 4 Figure 15 does not show any necessary protective devices for power circuit and control circuit, provisions for which are stated in 6.3 and 7.2.

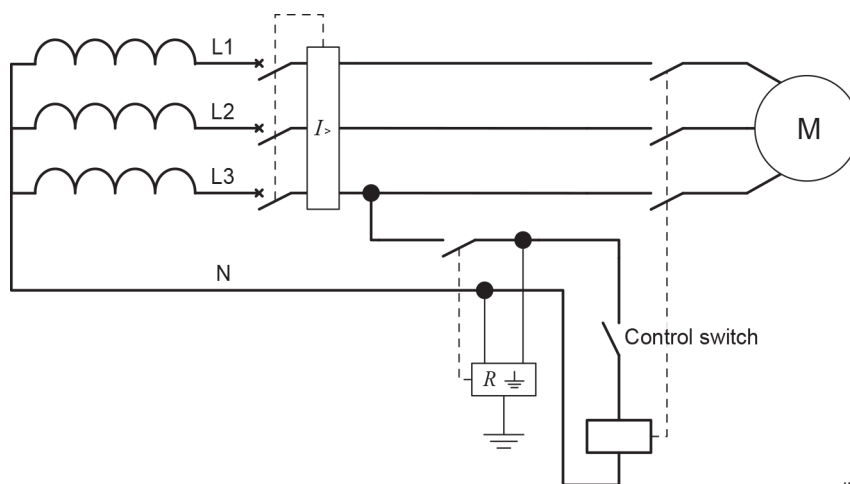


Figure 16 – Method d2a) Control circuit without transformer connected between phase and neutral of a non-earthed supply system

NOTE 5 Figure 16 does not show any necessary protective devices for the power circuit and control circuit, provisions for which are stated in 6.3 and 7.2.

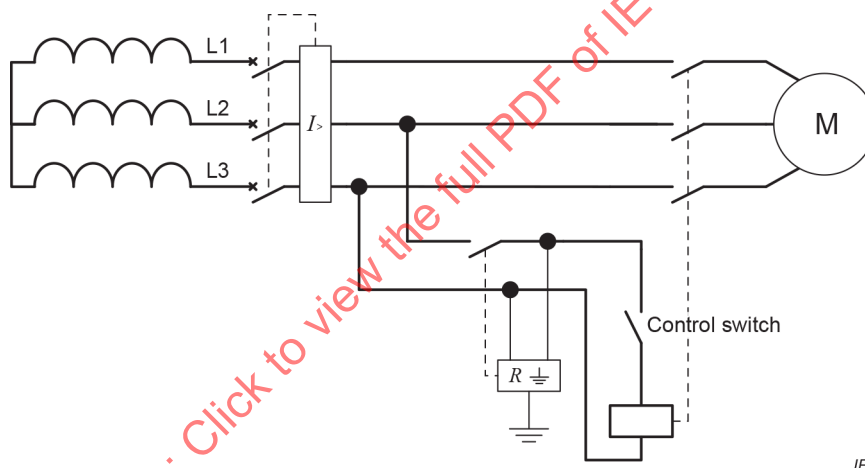


Figure 17 – Method d2b) control circuit without transformer connected between two phases of a non-earthed supply system

NOTE 6 Figure 17 does not show any necessary protective devices for power circuit and control circuit, provisions for which are stated in 6.3 and 7.2.

9.4.3.2 Voltage interruptions

See also 7.5.

Where the control system uses a memory device(s), proper functioning in the event of power failure shall be ensured (for example by using a non-volatile memory) to prevent any loss of memory that can result in a hazardous situation.

9.4.3.3 Loss of circuit continuity

Where the loss of continuity of control circuits depending upon sliding contacts can result in a hazardous situation, appropriate measures shall be taken (for example by duplication of the sliding contacts).

9.4.4 Protection against maloperation of a motion control system

In a motion control system for an electric motor(s), inadmissible control deviations which can cause a hazardous condition shall be detected automatically, the power to the motor(s) shall be switched off by a category 0 stop, and the mechanical brake system shall be applied.

In a hydraulic or pneumatic drive employing an energy converter, the motion shall be stopped if the electrical supply to the energy converter fails.

Triggering of any internal protective function of any component of the motion control system (e.g. overvoltage or overcurrent protection of adjustable speed drives, which are designed to protect the device itself) shall not cause loss of control of the motion nor uncontrolled motions.

10 Operator interface and hoisting machine mounted control devices

10.1 General

10.1.1 General requirements

This Clause 10 contains requirements for devices mounted outside or partially outside of control enclosures.

Control devices for operator interface shall, as far as is practicable, be selected, mounted, and identified or coded in accordance with IEC 61310 (all parts).

The possibility of inadvertent operation shall be minimized by, for example, positioning of devices, suitable design, provision of additional protective measures. Particular consideration shall be given to the selection, arrangement, programming and use of operator input devices such as touch screens, keypads and keyboards, for the control of hazardous hoisting machine operations, and of sensors (for example position sensors) that can initiate machine operation. Further information can be found in IEC 60447:2004.

Hand-held direct-control devices are permitted only for hoisting machines operating at rated values not exceeding 500 V AC and 7,5 kW. They shall be protected by fault protection in accordance with 6.3.2.2 (see also 9.1.2).

Ergonomic principles shall be taken into account in the location of operator interface devices.

10.1.2 Location and mounting

As far as is practicable, hoisting machine-mounted control devices shall be

- readily accessible for service and maintenance;
- mounted in such a manner as to minimize the possibility of damage from activities such as material handling.

The actuators of hand-operated control devices shall be selected and installed so that

- they are not less than 0,6 m above the servicing level and are within easy reach of the normal working position of the operator;
- the operator is not placed in a hazardous situation when operating them.

The actuators of foot-operated control devices shall be selected and installed so that

- they are within easy reach of the normal working position of the operator;
- the operator is not placed in a hazardous situation when operating them.

10.1.3 Protection

The degree of protection in accordance with IEC 60529 (IP rating) together with other appropriate measures shall provide protection against

- the effects of liquids, vapours, or gases found in the physical environment or used on the hoisting machine;
- the ingress of contaminants (e.g. dust, particulate matter).

In addition, the operator interface control devices shall have a minimum degree of basic protection of IPXXD (see IEC 60529).

10.1.4 Position sensors

Position sensors (e.g. position switches, proximity switches) shall be so arranged that they will not be damaged in the event of over-travel.

Position sensors in circuits with safety-related control functions (for example, to maintain the safe condition of the hoisting machine or prevent hazardous situations arising at the hoisting machine) shall have direct opening action (see IEC 60947-5-1:2016) or shall provide similar reliability (see 9.4.2).

10.1.5 Portable and pendant control stations

Portable and pendant operator control stations and their control devices shall be so selected and arranged as to minimize the possibility of hoisting machine operations caused by inadvertent actuation, shocks and vibrations (e.g. if the operator control station is dropped or strikes an obstruction) (see also 4.4.8).

Portable operation control stations (equipment) shall:

- be provided with means to reduce the probability of accidental dropping, for example a belt or neck strap;
- meet the following tests without visible damage or incorrect operation:
 - free fall test in accordance with IEC 60068-2-31:2008, Test Ec;
 - shock test in accordance with IEC 60068-2-27:2008, Test Ea.

10.2 Actuators

10.2.1 Colours

Actuators (see 3.1.1) are colour-coded as follows.

The colours for START/ON actuators should be WHITE, GREY, BLACK or GREEN with a preference for WHITE. RED shall not be used.

The colour RED shall be used for emergency stop and emergency switching-off actuators (including supply disconnecting devices where it is foreseen that they are for use in an emergency). If a background exists immediately around the actuator, then this background shall be coloured YELLOW. The combination of a RED actuator with a YELLOW background shall only be used for emergency operation devices.

The colours for STOP/OFF actuators should be BLACK, GREY, or WHITE with a preference for BLACK. GREEN shall not be used. RED is permitted, but it is recommended that RED is not used near an emergency operation device.

WHITE, GREY, or BLACK are the preferred colours for actuators that alternately act as START/ON and STOP/OFF actuators. The colours RED, YELLOW, or GREEN shall not be used.

WHITE, GREY, or BLACK are the preferred colours for actuators that cause operation while they are actuated and cease the operation when they are released (for example hold-to-run). The colours RED, YELLOW, or GREEN shall not be used.

Reset actuators shall be BLUE, WHITE, GREY, or BLACK. Where they also act as a STOP/OFF actuator, the colours WHITE, GREY, or BLACK are preferred with the main preference being for BLACK. GREEN shall not be used.

The colour YELLOW is reserved for use in abnormal conditions, for example, in the event of an abnormal condition of the process, or to interrupt an automatic cycle.

Where the same colour WHITE, GREY, or BLACK is used for various functions (for example WHITE for START/ON and for STOP/OFF actuators) a supplementary means of coding (for example shape, position, symbol) shall be used for the identification of actuators.

10.2.2 Markings

In addition to the functional identification as described in 16.3, recommended symbols to be placed near to or preferably directly on certain actuators are given in Table 2 and Table 3.

Table 2 – Symbols for actuators (power)

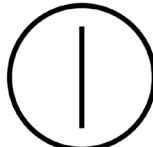
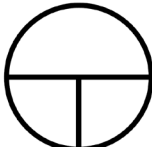
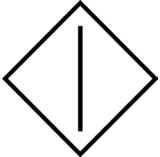
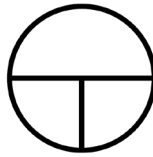
Power			
ON	OFF	ON/OFF (push on-push off)	ON (hold-to-run)
IEC 60417-5007 (2002-10)	IEC 60417-5008 (2002-10)	IEC 60417-5010 (2002-10)	IEC 60417-5011 (2002-10)
			

Table 3 – Symbols for actuators (machine operation)

Machine operation			
START	STOP	HOLD-TO-RUN	EMERGENCY STOP
IEC 60417-5104 (2006-08)	IEC 60417-5110A (2004-06)	IEC 60417-5011 (2002-10)	IEC 60417-5638 (2002-10)
			

10.3 Indicator lights, displays and audible devices

10.3.1 General

Indicator lights and displays serve to give the following types of information.

- Indication: to attract the operator's attention or to indicate that a certain task should be performed. The colours RED, YELLOW, BLUE, and GREEN are normally used in this mode; for flashing indicator lights and displays, see 10.3.3.
- Confirmation: to confirm a command, or a condition, or to confirm the termination of a change or transition period. The colours BLUE and WHITE are normally used in this mode and GREEN may be used in some cases.

Indicator lights and displays shall be selected and installed in such a manner as to be visible from the normal position of the operator (see also IEC 61310-1).

Circuits used for visual or audible devices used to warn persons of an impending hazardous event shall be fitted with facilities to check the operability of these devices.

10.3.2 Colours

Indicator lights shall be colour-coded with respect to the condition (status) of the hoisting machine in accordance with Table 4.

Table 4 – Colours for indicator lights and their meanings with respect to the condition of the hoisting machine

Colour	Meaning	Explanation	Action by operator
RED	Emergency	Hazardous condition	Immediate action to deal with hazardous condition (e.g. switching off the hoisting machine supply, being alert to the hazardous condition)
YELLOW	Abnormal	Abnormal condition Impending critical condition	Monitoring and/or intervention (e.g. by re-establishing the intended function)
BLUE	Mandatory	Indication of a condition that requires action by the operator	Mandatory action
GREEN	Normal	Normal condition	Optional
WHITE	Neutral	Other conditions may be used whenever doubt exists about the application of RED, YELLOW, GREEN, BLUE	Monitoring

Indicating towers on hoisting machines shall have the applicable colours in the following order from the top down when used vertically: RED, YELLOW, BLUE, GREEN and WHITE.

10.3.3 Flashing lights and displays

For further distinction or information and especially to give additional emphasis, flashing lights and displays can be provided for the following purposes:

- to attract attention;
- to request immediate action;
- to indicate a discrepancy between the command and actual state;
- to indicate a change in process (flashing during transition).

It is recommended that higher frequency flashing lights or displays be used for higher priority information (see IEC 60073:2002 for recommended flashing rates and pulse/pause ratios).

Where flashing lights or displays are used to provide higher priority information, audible warnings should also be provided.

10.4 Illuminated push-buttons

Illuminated push-button actuators shall be colour-coded in accordance with 10.2.1. Where there is difficulty in assigning an appropriate colour, WHITE shall be used.

The colour of active emergency stop actuators shall remain RED regardless of the state of the illumination.

10.5 Rotary control devices

Devices having a rotational member, such as potentiometers and selector switches, shall have means of prevention of rotation of the stationary member. Friction alone shall not be considered sufficient.

10.6 Start devices

Actuators used to initiate a start function or the movement of hoisting machine elements (e.g. trolleys) shall be constructed and mounted so as to minimize inadvertent operation.

10.7 Emergency stop devices

10.7.1 Location of emergency stop devices

Devices for emergency stop shall be readily accessible.

Emergency stop devices shall be provided:

- at each operator control station; and
- at other locations where the initiation of an emergency stop can be required, based on risk assessment.

When emergency stop devices are installed on detachable or cableless operator control stations (e.g. pluggable portable teaching pendants), at least one emergency stop device shall be permanently available (e.g. in a fixed position) on the hoisting machine.

Where required, emergency stop devices shall also be located outside the hoisting machine (e.g. operable at floor level in the case of overhead travelling cranes).

Non detachable emergency stop devices shall be active all the time even if the corresponding operator control station is not active.

For detachable emergency stop devices (e.g. operator control stations as standby devices with plug and socket combination), means shall be provided to avoid confusion whether the emergency stop device is active or not (e.g. information for use, keeping inactive operator control stations under lock and key).

For emergency stop devices of CCS, see also IEC 62745:2017.

The stopping of all motion drives from floor level may be dispensed with for those drives of the hoisting machine which may cause additional hazards; for example, on gantry cranes it may be sufficient to stop the gantry motion. On mobile cranes such devices may not be required at floor level.

10.7.2 Types of emergency stop device

The types of device for emergency stop include, but are not limited to:

- a push-button operated switch with a palm or mushroom head type;
- a pull-cord operated switch;
- a pedal-operated switch without a mechanical guard.

The devices shall be in accordance with IEC 60947-5-5.

10.7.3 Colour of actuators

Actuators of emergency stop devices shall be coloured RED. If a background exists immediately around the actuator, then this background shall be coloured YELLOW. See also ISO 13850:2015.

10.7.4 Local operation of the crane-supply-switch and the crane-disconnector to effect emergency stop

The crane-supply-switch and/or the crane-disconnector may be locally operated to serve the function of emergency stop when

- it is readily accessible to the operator; and
- it is of the type described in 5.3.2a), b), c), or d).

When also intended for such use, the crane-supply-switch and/or the crane-disconnector shall conform to the colour requirements of 10.7.3.

NOTE This device is usually not located at the operator control station and, therefore, it cannot be used as the only emergency stop device (see 10.7.1 and 10.8.1).

10.8 Emergency switching-off devices

10.8.1 Location of emergency switching-off devices

The device shall be capable of being operated from an easily and quickly accessible location near to the hoisting machine, either direct, or remotely. According to a risk assessment the provision of emergency switching-off facilities may also be necessary for other locations in which live conductors may be exposed in normal service (see also 9.2.5.4.3 and 12.7.1).

Normally, those devices will be located separate from operator control stations. Where confusion can occur between emergency stop and emergency switching-off devices, means shall be provided to minimize confusion.

NOTE This can be achieved by, for example, the provision of a break-glass enclosure for the emergency switching-off device.

10.8.2 Types of emergency switching-off device

The types of devices for initiation of emergency switching-off include

- a push-button operated switch with a palm or mushroom head type of actuator;
- a pull-cord operated switch.

The devices shall have direct opening action (see Annex K of IEC 60947-5-1:2016).

10.8.3 Colour of actuators

Actuators of emergency switching-off devices shall be coloured RED. If a background exists immediately around the actuator then this background shall be coloured YELLOW.

10.8.4 Local operation of the crane-supply-switch and the crane-disconnector to effect emergency switching-off

Where the crane-supply-switch or the crane-disconnector is to be locally operated for emergency switching-off, it shall be readily accessible and shall meet the colour requirements of 10.8.3.

The crane-disconnector shall have sufficient breaking capability if used for emergency switching-off.

10.9 Enabling control device

When an enabling control device is provided as a part of a system, it shall signal the enabling control to allow operation when actuated in one position only. In any other position, operation shall be stopped or prevented.

Enabling control devices shall be selected and arranged so as to minimize the possibility of defeating.

Enabling control devices shall be selected that have the following features.

- Designed in accordance with ergonomic principles.
- For a two-position type:
 - position 1: off-function of the switch (actuator is not operated);
 - position 2: enabling function (actuator is operated).
- For a three-position type:
 - position 1: off-function of the switch (actuator is not operated);
 - position 2: enabling function (actuator is operated in its mid position);
 - position 3: off-function (actuator is operated past its mid position);
 - when returning from position 3 to position 2, the enabling function is not activated.

NOTE 1 The enabling control function is described in 9.2.6.3.

NOTE 2 IEC 60947-5-8 specifies requirements for three-position enabling switches.

11 Controlgear: location, mounting and enclosures

11.1 General requirements

All controlgear shall be located and mounted so as to facilitate

- its accessibility and maintenance;
- its protection against the external influences or conditions under which it is intended to operate;
- operation and maintenance of the hoisting machine and its associated equipment.

11.2 Location and mounting

11.2.1 Accessibility and maintenance

All items of controlgear shall be placed and oriented so that they can be identified without moving them or the wiring. For items that require checking for correct operation or that are liable to need replacement, those actions should be possible without dismantling other equipment or parts of the hoisting machine (except opening doors or removing covers, barriers or obstacles). Terminals not part of controlgear components or devices shall also conform to these requirements.

All controlgear shall be mounted so as to facilitate its operation and maintenance. Where a special tool is necessary to adjust, maintain, or remove a device, such a tool shall be supplied. Where access is required for regular maintenance or adjustment, the relevant devices shall be located between 0,4 m and 2,0 m above the servicing level. It is recommended that terminals be at least 0,2 m above the servicing level and be so placed that conductors and cables can be easily connected to them.

No devices except devices for operating, indicating, measuring, and cooling shall be mounted on doors or on normally removable access covers of enclosures. Where control devices are connected through plug-in arrangements, their association shall be made clear by type (shape), marking or reference designation, singly or in combination (see 13.4.5).

Plug-in devices that are handled during normal operation shall be provided with non-interchangeable features where the lack of such a facility can result in malfunctioning.

Plug/socket combinations that are handled during normal operation shall be located and mounted so as to provide unobstructed access.

Test points for connection of test equipment, where provided, shall be

- mounted so as to provide unobstructed access;
- clearly identified to correspond with the documentation;
- adequately insulated;
- sufficiently spaced.

11.2.2 Physical separation or grouping

Non-electrical parts and devices, not associated direct with the electrical equipment, shall not be located within enclosures containing controlgear. Devices such as solenoid valves should be separated from the other electrical equipment (e.g. in a separate compartment).

Control devices mounted in the same location and connected to the power circuits, or to both power circuits and control circuits, should be grouped separately from those connected only to the control circuits.

Terminals shall be separated into groups for

- power circuits;
- associated control circuits of the hoisting machine;
- other control circuits, fed from external sources (e.g. for interlocking).

The groups may be mounted adjacently, provided that each group can be readily identified (e.g. by markings, by use of different sizes, by use of barriers or by colours).

When arranging the location of devices (including interconnections), the clearances and creepage distances specified for them by the supplier shall be maintained, taking into account the external influences or conditions of the physical environment.

11.2.3 Heating effects

The temperature inside electrical equipment enclosures shall not exceed the ambient temperature specified by the component manufacturers.

NOTE 1 IEC TR 60890 can be used for the calculation of temperature rise inside enclosures.

Heat generating components (e.g. heat sinks, power resistors) shall be so located that the temperature of each component in the vicinity remains within the permitted limit.

NOTE 2 Information on the selection of insulating materials to resist thermal stresses is given in IEC 60216 and IEC 60085.

Consideration shall be given to avoid excessive heating of the environment of the hoisting machine (e.g. braking resistors of adjustable speed drives can cause fire hazards in dusty environment or when the hoisting machine is parked adjacent to sensitive material).

11.3 Degrees of protection

The protection of controlgear against ingress of solid foreign objects and of liquids shall be adequate taking into account the external influences under which the hoisting machine is intended to operate (i.e. the location and the physical environmental conditions) and shall be sufficient against dust, coolants, lubricants and swarf.

NOTE 1 The degrees of protection against ingress of water are covered by IEC 60529. Additional protective measures can be necessary against other liquids.

Enclosures of controlgear shall provide a degree of protection of at least IP22 (see IEC 60529).

Exception: an enclosure providing a minimum degree of protection IP22 is not required where

- a) an electrical operating area provides an appropriate degree of protection against ingress of solids and liquids, or
- b) removable collectors on conductor wire or conductor bar systems are used and the measures of 6.2.5 are applied.

NOTE 2 Some examples of applications, along with the degree of protection typically provided by their enclosures, are listed below.

– Ventilated enclosure, containing braking resistor or similar equipment	IP10
– Enclosure containing electrical equipment	IP32, IP43 and IP54
– Enclosure used in outdoor applications or locations that are cleaned with low-pressure water jets (hosing)	IP55
– Enclosure providing protection against fine dust	IP65
– Enclosure containing slip-ring assemblies	IP2X

Depending upon the conditions where installed, another degree of protection can be appropriate.

11.4 Enclosures, doors and openings

Enclosures shall be constructed using materials capable of withstanding the mechanical, electrical and thermal stresses as well as the effects of humidity and other environmental factors that are likely to be encountered in normal service.

Windows of enclosures shall be of a material suitable to withstand expected mechanical stress and chemical attack.

It is recommended that enclosure doors are not wider than 0,9 m and have vertical hinges, with an angle of opening of at least 95°.

The joints or gaskets of doors, lids, covers and enclosures shall withstand the chemical effects of the aggressive liquids, vapours, or gases in the environment of the hoisting machine (see Annex B). The means provided to maintain the degree of protection of an enclosure on doors, lids and covers that require opening or removal for operation or maintenance shall

- be securely attached to either the door/cover or the enclosure;
- not deteriorate due to removal or replacement of the door or the cover and so impair the degree of protection.

Where openings in enclosures are provided (e.g. for cable access), including those towards the floor or foundation or to other parts of the hoisting machine, means shall be provided to ensure the degree of protection specified for the equipment. Openings for cable entries shall be easily re-opened on site. A suitable opening may be provided in the base of enclosures within the hoisting machine so that moisture due to condensation can drain away.

There shall be no opening between enclosures containing electrical equipment and compartments containing coolant, lubricating or hydraulic fluids, or those into which oil, other liquids, or dust can penetrate. This requirement does not apply to electrical devices specifically designed to operate in oil (e.g. electromagnetic clutches) nor to electrical equipment in which coolants are used.

Where there are holes in an enclosure for mounting purposes, means may be necessary to ensure that, after mounting, the holes do not impair the required protection.

Equipment that, in normal or abnormal operation, can attain a surface temperature sufficient to cause a risk of fire or detrimental effect to an enclosure material

- shall be located within an enclosure that will withstand, without risk of fire or harmful effect, such temperatures as can be generated;
- shall be mounted and located at a sufficient distance from adjacent equipment so as to allow safe dissipation of heat (see also 11.2.3);
- shall be otherwise screened by material that can withstand, without risk of fire or harmful effect, the heat emitted by the equipment.

A warning label in accordance with 16.2.2 should be applied.

11.5 Access to switchgear and to controlgear

11.5.1 General

Dimensions of operating and maintenance gangways in front of and between switchgear and controlgear shall be sufficient for safe operation and maintenance of electrical equipment. The minimum dimensions are defined in 11.5.2 and 11.5.3.

Depending on the risk assessment, the requirements set out in 11.5.2 and 11.5.3 do not apply to enclosures containing only terminals and other components which require minimal maintenance (e.g. resistors).

NOTE Further information is given in IEC 60364-7-729.

11.5.2 Access to gangways

Operating and maintenance gangways of a length of 20 m and longer shall be accessible from both ends. For gangways shorter than 20 m, but exceeding 10 m, access from both ends is recommended.

Doors in gangways and for access to electrical operating areas which readily allow a person to fully enter shall

- be at least 0,7 m wide and 2,0 m high;
- open outwards;
- have a means (e.g. panic bolts) to allow opening from the inside without the use of a key or tool;
- have a sufficient clearance for opening fully.

Exception: Where the dimensions of gangways and/or doors have to be locally reduced, for example, at bulkheads necessary for stiffening in box girders, the clear height may be reduced to not less than 1,4 m and/or the clear width to not less than 0,6 m at these points.

Where the measures provided for protection against unintended contact with live parts along the gangway are not sufficient for the areas immediately adjacent to these restrictions, additional measures for protection can be required (see 6.2).

11.5.3 Gangways in front of switchgear and controlgear

The clear width in front of switchgear and controlgear enclosures shall be at least 0,6 m, and for passing open enclosure doors shall be at least 0,4 m measured with the maximum door opening angle.

Enclosures which readily allow a person to fully enter, for example, for resetting, adjusting or maintenance, shall have a clear width of at least 0,7 m and a clear height of at least 2,0 m.

In cases where

- equipment is likely to be live during access, and
- conducting parts are exposed,

the clear width shall be at least 0,9 m. In cases where such parts are present on both sides of the access way, the clear width shall be at least 1,3 m.

12 Conductors and cables

12.1 General requirements

Conductors and cables shall be selected so as to be suitable for the operating conditions (e.g. voltage, current, protection against electric shock, grouping of cables) and external influences (e.g. ambient temperature, presence of water or corrosive substances, mechanical stresses (including stresses during installation), fire hazards) that can exist.

These requirements do not apply to the integral wiring of assemblies, subassemblies, and devices that are manufactured and tested in accordance with their relevant IEC standard (e.g. IEC 61800 series).

When cables are installed on hoisting machines used in the open air (e.g. outside buildings or other protective structures), they shall be suitable for outdoor use (e.g. UV-resistant, adequate temperature range), or be otherwise protected (e.g. cable duct or other housing).

12.2 Conductors

Conductors should be of copper. Where aluminium conductors are used, the cross-sectional area shall be at least 16 mm².

To ensure adequate mechanical strength, the cross-sectional area of conductors shall not be less than as shown in Table 5. However, conductors with smaller cross-sectional areas or other constructions than shown in Table 5 may be used in equipment provided adequate mechanical strength is achieved by other means and proper functioning is not impaired.

Table 5 – Minimum cross-sectional areas of copper conductors

		Type of conductor, cable				
Location	Application	Single core		Multi-core		
		Flexible (class 5 or class 6)	Solid (class 1) or stranded (class 2)	Two core, shielded	Two core, not shielded	Three or more cores, shielded or not
Wiring outside (protecting) enclosures	Power circuits, fixed	1,0	1,5	0,75	0,75	0,75
	Power circuits, subjected to frequent movements	1,0	-	0,75	0,75	0,75
	Control circuits	1,0	1,0	0,2	0,5	0,2
	Data communication	-	-	-	-	0,08
Wiring inside enclosures ^a	Power circuits (connections not moved)	0,75	0,75	0,75	0,75	0,75
	Control circuits	0,2	0,2	0,2	0,2	0,2
	Data communication	-	-	-	-	0,08
NOTE 1 All cross-sections in mm ² .						
NOTE 2 Annex F contains a comparison of typical conductor cross-sectional areas in American Wire Gauge (AWG), square millimetres, square inches, and circular mils.						
^a Except special requirements of individual standards; see also 12.1.						

NOTE Classification of conductors is given in Table 6.

Table 6 – Classification of conductors

Class	Description	Use/application
1	Solid copper or aluminium conductors	Fixed installations
2	Stranded copper or aluminium conductors	
5	Flexible stranded copper conductors	Machine installations with presence of vibration; connection to moving parts
6	Flexible stranded copper conductors that are more flexible than class 5	For frequent movements
NOTE Derived from IEC 60228.		

Class 1 and class 2 conductors are primarily intended for use between rigid, non-moving parts, and they may also be used where minimal flexing occurs provided that the cross-sectional area is less than 0,5 mm².

All conductors that are subject to frequent movement (e.g. one movement per hour of machine operation) shall have flexible stranding of class 5 or class 6.

12.3 Insulation

Where the insulation of conductors and cables can constitute hazards due for example to the propagation of a fire or the emission of toxic or corrosive fumes, guidance from the cable supplier should be sought. It is important to give special attention to the integrity of a circuit having a safety-related control function.

The insulation of cables and conductors used shall be suitable for a test voltage:

- not less than 2 000 V AC for a duration of 5 min for operating at voltages higher than 50 V AC or 120 V DC; or
- not less than 500 V AC for a duration of 5 min for PELV circuits (see IEC 60364-4-41:2005, class III equipment).

The mechanical strength and thickness of the insulation shall be such that the insulation cannot be damaged in operation or during laying, especially for cables pulled into ducts.

The effects of voltage and current waveform should be taken into account when selecting cables, for example adjustable speed drives can cause additional voltage stresses to the motor cable (see IEC 61800 series).

12.4 Current-carrying capacity in normal service

The current-carrying capacity depends on several factors, for example, insulation material, number of conductors in a cable, design (sheath), methods of installation, grouping and ambient temperature.

NOTE 1 Detailed information and further guidance can be found in IEC 60364-5-52, in some national standards or given by the manufacturer.

One typical example of the current-carrying capacities for PVC insulated wiring between enclosures and individual items of equipment under steady-state conditions is given in Table 7.

NOTE 2 For specific applications where the correct cable dimensioning can depend on the relationship between the period of the duty cycle and the thermal time constant of the cable (for example starting against high-inertia load, intermittent duty), the cable manufacturer can provide information. If such information is not available, the criteria presented in Annex D can be used.

Table 7 – Examples of current-carrying capacity (I_z) of PVC-insulated copper conductors or cables under steady-state conditions in an ambient air temperature of +40 °C for different methods of installation

	Installation method (see C.2.2)			
	B1	B2	C	E
Cross-sectional area mm ²	Current-carrying capacity I_z for three-phase circuits			
	A			
0,75	8,6	8,5	9,8	10,4
1,0	10,3	10,1	11,7	12,4
1,5	13,5	13,1	15,2	16,1
2,5	18,3	17,4	21	22
4	24	23	28	30
6	31	30	36	37
10	44	40	50	52
16	59	54	66	70
25	77	70	84	88
35	96	86	104	110
50	117	103	125	133
70	149	130	160	171
95	180	156	194	207
120	208	179	225	240
	Control circuit pairs			
0,20	4,5	4,3	4,4	4,4
0,5	7,9	7,5	7,5	7,8
0,75	9,5	9,0	9,5	10

NOTE 1 The values of the current-carrying capacity of Table 7 are based on:

- one symmetrical three-phase circuit for cross-sectional areas 0,75 mm² and greater;
- one control circuit pair for cross-sectional areas between 0,2 mm² and 0,75 mm².

Where more loaded cables/pairs are installed, derating factors for the values of Table 7 can be found in Table C.2 or Table C.3.

NOTE 2 For ambient temperatures other than 40 °C, correction factors for current-carrying capacities are provided in Table C.1.

NOTE 3 These values are not applicable to flexible cables wound on drums (see 12.6.3).

NOTE 4 Current-carrying capacities of other cables are provided in IEC 60364-5-52.

12.5 Conductor and cable voltage drop

The voltage drop from the crane-supply-switch to the motors or, in the case of a semiconductor converter driven motor, to the line side of the converter, shall not exceed 5 % of the nominal voltage under normal operating conditions. In order to conform to this requirement, it may be necessary to use conductors having a larger cross-sectional area than that derived from Table 7.

NOTE If more information is not available, the voltage drop can be calculated by using the starting current of the largest drive combined with the nominal current of the next largest drive. When there is more than one hoisting machine on a common power supply, a proven simultaneity factor can be used.

In control circuits, the voltage drop shall not reduce the voltage at any device below the manufacturer's specification for that device, taking into account inrush currents.

The voltage drop in components, for example overcurrent protective devices and switching devices, should be considered.

12.6 Flexible cables

12.6.1 General

Flexible cables shall have class 5 or class 6 conductors.

NOTE 1 Class 6 conductors have smaller diameter strands and are more flexible than class 5 conductors (see Table 6).

Cables that are subjected to severe duties shall be of adequate construction to protect against

- abrasion due to mechanical handling and dragging across rough surfaces;
- kinking due to operation without guides;
- stress resulting from guide rollers and forced guiding, being wound and re-wound on cable drums.

NOTE 2 Cables for such conditions are specified in national standards.

NOTE 3 The operational life of the cable will be reduced where unfavourable operating conditions such as high tensile stress, small radii, bending into another plane and/or where frequent duty cycles coincide.

12.6.2 Mechanical rating

The cable-handling system of the hoisting machine shall be so designed to keep the tensile stress of the conductors as low as is practicable during hoisting machine operations. Where copper conductors are used, the tensile stress applied to the conductors shall not exceed 15 N/mm² of the copper cross-sectional area. Where the demands of the application exceed the tensile stress limit of 15 N/mm², cables with special construction features should be used and the allowed maximum tensile stress should be agreed with the cable manufacturer.

The maximum stress applied to the conductors of flexible cables with material other than copper shall be within the cable manufacturer's specification.

NOTE The following conditions affect the tensile stress on the conductors:

- acceleration forces;
- speed of motion;
- dead (hanging) weight of the cables;
- method of guiding;
- design of cable drum system.

12.6.3 Current-carrying capacity of cables wound on drums

Cables to be wound on drums shall be selected with conductors having a cross-sectional area such that, when fully wound on the drum and carrying the normal service load, the maximum allowable conductor temperature is not exceeded.

For cables of circular cross-sectional area installed on drums, the maximum current-carrying capacity in free air shall be derated in accordance with Table 8.

NOTE The current-carrying capacity of cables in free air can be found in manufacturers' specifications or in relevant national standards.

Table 8 – Derating factors for cables wound on drums

Drum type	Number of layers of cable				
	Any number	1	2	3	4
Cylindrical ventilated	–	0,85	0,65	0,45	0,35
Radial ventilated	0,85	–	–	–	–
Radial non-ventilated	0,75	–	–	–	–
It is recommended that the use of derating factors be discussed with the cable and the cable drum manufacturers. This may result in other factors being used.					
NOTE 1 A radial type drum is one where spiral layers of cable are accommodated between closely spaced flanges; if fitted with solid flanges, the drum is described as non-ventilated and, if the flanges have suitable apertures, as ventilated.					
NOTE 2 A ventilated cylinder drum is one where the layers of cable are accommodated between widely spaced flanges and the drum and end flanges have ventilating apertures.					

12.7 Conductor wires, conductor bars and slip-ring assemblies

12.7.1 Basic protection

Conductor wires, conductor bars and slip-ring assemblies shall be installed or enclosed in such a way that, during normal access to the hoisting machines (for example, via gangways along a crane track or along a crane girder), basic protection is achieved by the application of one of the following protective measures:

- protection by partial insulation of live parts or, where this is not practicable,
- protection by enclosures or barriers of at least IP2X or IPXXB (see IEC 60364-4-41:2005, Clause A.2).

Horizontal top surfaces of barriers or enclosures which are readily accessible shall provide a degree of protection of at least IP4X or IPXXD.

Where the required degree of protection is not achieved, one of the following additional protective measures shall be applied:

- a) protection by placing live parts out of reach (see IEC 60364-4-41:2005, Clause B.3) in combination with emergency switching-off in accordance with 9.2.5.4.3 or, where this is not practicable,
- b) protection by compliance with the limits (derived from ISO 13857) given in Figure 18, Figure 19 and Figure 20. This measure is intended to be used in areas where only skilled or instructed persons have access and where special conditions exist (e.g. hot area of steel mills or in chemical plants).

Dimensions in millimetres

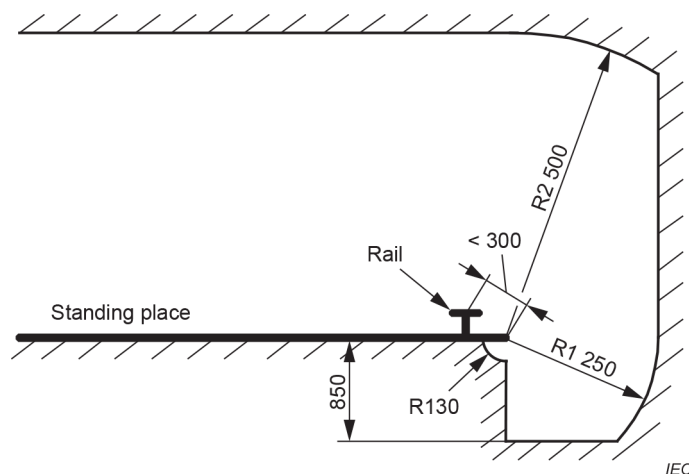


Figure 18 – Limit of arm's reach in cases where the distance from the middle of the hoisting device-rail to the edge of the girder is less than 300 mm

Dimensions in millimetres

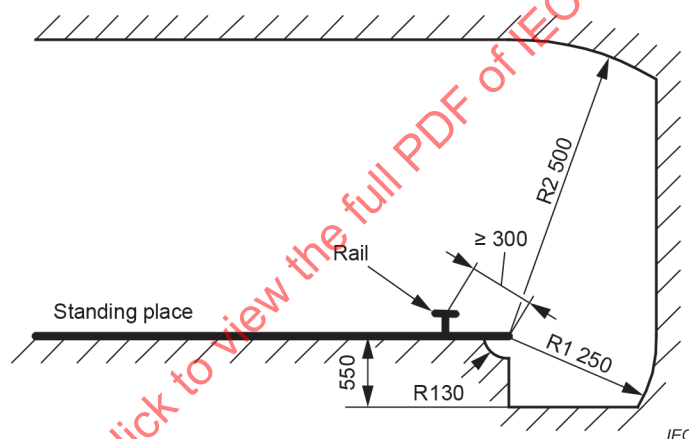


Figure 19 – Limit of arm's reach in cases where the distance from the middle of the hoisting device-rail to the edge of the girder is at least 300 mm

Dimensions in millimetres

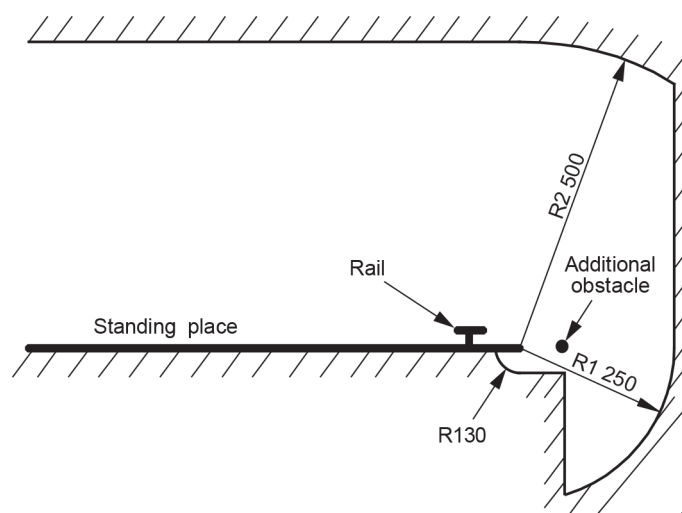


Figure 20 – Limit of arm's reach in cases of using additional obstacles

NOTE Examples of obstacles located above unprotected conductor wires or conductor bars are guard-rails, mesh-screens.

Conductor wires and conductor bars shall be so placed and/or protected as to

- prevent contact, especially for unprotected conductor wires and conductor bars, with conductive items such as the cords of pull-cord switches, strain-relief devices and drive chains;
- prevent damage from a swinging load.

Where the required degree of protection provided for conductor wires or conductor bars is not effective (e.g. adjacent to current collectors), additional means shall be provided (e.g. additional obstacles).

If circuits of different crane-disconnectors are run through conductor wires, conductor bars or slip-ring assemblies, each subcircuit system shall be protected against direct contact with a degree of protection of at least IP2X or IPXXB (see IEC 60529).

12.7.2 Protective conductor circuit

Where conductor wires, conductor bars and slip-ring assemblies are installed as part of the protective bonding circuit, they shall not carry current in normal operation. Therefore, the protective conductor (PE) and the neutral conductor (N) shall each use a separate conductor wire, conductor bar or slip-ring. The continuity of the protective conductor circuit using sliding contacts shall be ensured by taking appropriate measures (e.g. duplication of the current collector, continuity monitoring).

12.7.3 Protective conductor current collectors

Protective conductor current collectors shall have a shape or construction so that they are not interchangeable with the other current collectors. Such current collectors shall be of the sliding contact type.

It is recommended that protective current collectors be identified by the colour combination GREEN-AND-YELLOW or marked by symbol IEC 60417-5019 (2006-08) (see Figure 21) or symbol PE, at least at connection points.

12.7.4 Removable current collectors with a disconnecter function

Removable current collectors having a disconnecter function shall be so designed that the protective conductor circuit is interrupted only after the live conductors have been disconnected, and the continuity of the protective conductor circuit is re-established before any live conductor is reconnected (see also 8.2.4).

12.7.5 Clearances in air

Clearances between the respective conductors, and between adjacent systems, of conductor wires, conductor bars, slip-ring assemblies and their current collectors shall be suitable for at least a rated impulse voltage of an overvoltage category III in accordance with IEC 60664-1.

12.7.6 Creepage distances

Creepage distances between the respective conductors, and between adjacent systems of conductor wires, conductor bars and slip-ring assemblies, and their current collectors shall be suitable for operation in the intended environment, for example open air, inside buildings, protected by enclosures.

NOTE Equipment designed to operate in pollution degree 3 conditions is suitable for most applications.

In abnormally dusty, moist or corrosive environments, the following creepage distance requirements apply.

- Unprotected conductor wires, conductor bars, and slip-ring assemblies shall be equipped with insulators with a minimum creepage distance of 60 mm.
- Enclosed conductor wires, insulated multi-pole conductor bars and insulated individual conductor bars shall have a minimum creepage distance of 30 mm.

The manufacturer's recommendations shall be followed regarding special measures to prevent a gradual reduction in the insulation values due to unfavourable ambient conditions (e.g. deposits of conductive dust, chemical attack).

12.7.7 Conductor system sectioning

Where conductor wires or conductor bars are arranged so that they can be divided into isolated sections, suitable design measures shall be employed to prevent the energization of adjacent sections by the current collectors themselves.

12.7.8 Construction and installation of conductor wire, conductor bar systems and slip-ring assemblies

Conductor wires, conductor bars and slip ring assemblies used for power circuits shall be grouped separately from those used for control circuits.

Conductor wires, conductor bars and slip-ring assemblies shall be capable of withstanding, without damage, the mechanical forces and thermal effects of short-circuit currents.

Removable covers for conductor wire and conductor bar systems laid underground or underfloor shall be so designed that they cannot be opened by one person without the aid of a tool.

Where conductor bars are installed in a common metal enclosure, the individual sections of the enclosure shall be bonded together and earthed at several points depending upon their length. Metal covers of conductor bars laid underground or underfloor shall also be bonded together and connected to the protective bonding circuit.

The protective bonding circuit shall include the covers or cover plates of metal enclosures or underfloor ducts. Where metal hinges form a part of the protective bonding circuit, their continuity shall be verified (see Clause 18).

Conductor bar ducts that can be subject to accumulation of liquid such as oil or water shall have drainage facilities.

13 Wiring practices

13.1 Connections and routing

13.1.1 General requirements

All connections, especially those of the protective bonding circuit shall be secured against accidental loosening.

The means of connection shall be suitable for the cross-sectional areas and nature of the conductors being terminated.

The connection of two or more conductors to one terminal is permitted only in those cases where the terminal is designed for that purpose. However, only one protective conductor shall be connected to one terminal connecting point.

Soldered connections shall only be permitted where terminals are provided that are suitable for soldering.

Terminals on terminal blocks shall be plainly marked or labelled to correspond with the identification used in the diagrams.

NOTE IEC 61666 provides rules that can be used for the designation of terminals within the electrical equipment.

Where an incorrect electrical connection (e.g. arising from replacement of devices) is identified as a source of risk that needs to be reduced and it is not practicable to reduce the possibility of incorrect connection by design measures, the conductors and/or terminations shall be identified.

The installation of flexible conduits and cables shall be such that liquids shall drain away from the fittings.

Means of retaining conductor strands shall be provided when terminating conductors at devices or terminals that are not equipped with this facility. Solder shall not be used for that purpose.

Shielded conductors shall be so terminated as to prevent fraying of strands and to permit easy disconnection.

Identification tags shall be legible, permanent, and appropriate for the physical environment.

Terminal blocks shall be mounted and wired so that the wiring does not cross over the terminals.

13.1.2 Conductor and cable runs

Conductors and cables shall be run from terminal to terminal without splices or joints. Connections using plug/socket combinations with suitable protection against accidental disconnection are not considered to be splices or joints for the purpose of 13.1.2.

Exception: Where it is impracticable to provide terminals in a junction box (e.g. on hoisting machines having long flexible cables; cable connections exceeding a length which is not practical to be supplied by the cable manufacturer on one cable drum), splices or joints may be used.

Where it is necessary to connect and disconnect cables and cable assemblies, a sufficient extra length shall be provided for that purpose.

The terminations of cables shall be adequately supported to prevent mechanical stresses at the terminations of the conductors.

Wherever practicable, the protective conductor shall be placed close to the associated live conductors in order to decrease the impedance of the loop.

13.1.3 Conductors of different circuits

Conductors of different circuits may be laid side by side, may occupy the same duct (e.g. conduit, cable trunking system), or may be in the same multi-conductor cable or in the same plug/socket combination provided that the arrangement does not impair the proper functioning of the respective circuits and:

- where those circuits operate at different voltages, the conductors shall be separated by suitable barriers or
- the conductors shall be insulated for the highest voltage to which any conductor within the same duct can be subjected, for example line-to-line voltage for unearthed systems and phase-to-earth voltage for earthed systems.

13.1.4 AC circuits – Electromagnetic effects (prevention of eddy currents)

Conductors of AC circuits installed in ferromagnetic enclosures shall be arranged so that all conductors of each circuit, including the protective conductor of each circuit, are contained in the same enclosure. Where such conductors enter a ferrous enclosure, they shall be arranged such that the conductors are not individually surrounded by ferromagnetic material.

Single-core cables armoured with steel wire or steel tape should not be used for AC circuits.

The steel wire or steel tape armour of a single-core cable is regarded as a ferromagnetic enclosure. For single-core wire armoured cables, the use of aluminium armour is recommended.

NOTE See also IEC 60364-5-52.

13.1.5 Connection between pick-up and pick-up converter of an inductive power supply system

The cable between the pick-up and the pick-up converter shall be

- as specified by the power supply system manufacturer;
- as short as practicable;
- adequately protected against mechanical damage.

NOTE The output of the pick-up can be a current source; therefore, damage to the cable can result in a high voltage hazard.

13.2 Identification of conductors

13.2.1 General requirements

Each conductor shall be identifiable at each termination in accordance with the technical documentation (see Clause 17).

It is recommended (e.g. to facilitate maintenance) that conductors be identified by number, alphanumeric, colour (either solid or with one or more stripes), or a combination of colour and numbers or alphanumeric. When numbers are used, they shall be arabic; letters shall be roman (either upper- or lower-case).

NOTE 1 Annex B can be used for agreement between supplier and user regarding a preferred method of identification.

NOTE 2 IEC 62491 provides rules and guidelines for the labelling of cables and cores/conductors used in industrial installations, equipment and products.

13.2.2 Identification of the protective conductor / protective bonding conductor

The protective conductor / protective bonding conductor shall be readily distinguishable from other conductors by shape, location, marking, or colour. When identification is by colour alone, the bicolour combination GREEN-AND-YELLOW shall be used throughout the length of the conductor. This colour identification is strictly reserved for the protective conductor / protective bonding conductors.

For insulated conductors, the bicolour combination GREEN-AND-YELLOW shall be such that on any 15 mm length one of the colours covers at least 30 % and not more than 70 % of the surface of the conductor, the other colour covering the remainder of the surface.

Where the protective conductor can be easily identified by its shape, position, or construction (e.g. a braided conductor, uninsulated stranded conductor), or where the insulated conductor is not readily accessible or is part of a multicore cable, colour coding throughout its length is not necessary but the ends or accessible locations shall be clearly identified by the graphical symbol IEC 60417-5019 (2006-08) (see Figure 21) or with the letters PE or by the bicolour combination GREEN-AND-YELLOW.

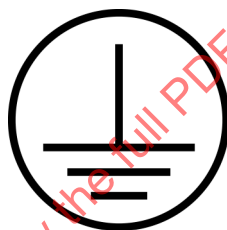


Figure 21– Symbol IEC 60417-5019

Exception: Protective bonding conductors may be marked with the letters PB and/or the symbol IEC 60417-5021 (2002-10) (see Figure 22).



Figure 22 – Symbol IEC 60417-5021

13.2.3 Identification of the neutral conductor

Where a circuit includes a neutral conductor that is identified by colour alone, the colour used for this conductor shall be BLUE. In order to avoid confusion with other colours, it is recommended that an unsaturated blue be used, called here “light blue” (see 6.2.2 of IEC 60445:2021). Where the selected colour is the sole identification of the neutral conductor, that colour shall not be used for identifying any other conductor where confusion is possible.

Where identification by colour is used, bare conductors used as neutral conductors shall be either coloured by a stripe, 15 mm to 100 mm wide in each compartment or unit and at each accessible location, or coloured throughout their length.

13.2.4 Identification by colour

Where colour-coding is used for identification of conductors (other than the protective conductor (see 13.2.2) and the neutral conductor (see 13.2.3)), the following colours may be used:

BLACK, BROWN, RED, ORANGE, YELLOW, GREEN, BLUE (including LIGHT BLUE), VIOLET, GREY, WHITE, PINK, TURQUOISE.

NOTE This list of colours is derived from IEC 60757.

It is recommended that, where colour is used for identification, the colour be used throughout the length of the conductor either by the colour of the insulation or by colour markers at regular intervals and at the ends or accessible location.

For safety reasons, the colour GREEN or the colour YELLOW should not be used where there is a possibility of confusion with the bicolour combination GREEN-AND-YELLOW (see 13.2.2).

Colour identification using combinations of those colours listed above may be used provided there can be no confusion and that GREEN or YELLOW is not used except in the bicolour combination GREEN-AND-YELLOW.

Where colour-coding is used for identification of conductors, it is recommended that they be colour-coded as follows:

- BLACK: AC and DC power circuits;
- RED: AC control circuits;
- BLUE: DC control circuits;
- ORANGE: special circuits in accordance with 5.3.8.

Exceptions to the above are permitted where insulation is not available in the colours recommended (for example in multiconductor cables).

13.3 Wiring inside enclosures

Conductors inside enclosures shall be supported where necessary to keep them in place. Non-metallic ducts shall be permitted only when they are made with a flame-retardant insulating material (see the IEC 60332 series).

It is recommended that electrical equipment mounted inside enclosures be designed and constructed in such a way as to permit modification of the wiring from the front of the enclosure (see also 11.2.1). Where that is not practicable and control devices are connected from the rear of the enclosure, access doors or swing-out panels shall be provided.

Connections to devices mounted on doors or to other movable parts shall be made using flexible conductors in accordance with 12.2 and 12.6 to allow for the frequent movement of the part. The conductors shall be anchored to the fixed part and to the movable part independently of the electrical connection (see also 8.2.3 and 11.2.1).

Conductors and cables that do not run in ducts shall be adequately supported.

Terminal blocks or plug/socket combinations shall be used for control wiring that extends beyond the enclosure. For plug/socket combinations, see also 13.4.5 and 13.4.6.

Power cables and cables of measuring circuits may be directly connected to the terminals of the devices for which the connections were intended.

13.4 Wiring outside enclosures

13.4.1 General requirements

The means of introduction of cables or ducts with their individual glands, bushings, etc., into an enclosure shall ensure that the degree of protection is not reduced (see 11.3).

Conductors of a circuit shall not be distributed over different multi-core cables, conduits, cable ducting systems or cable trunking systems. This is not required where a number of multi-core cables, forming one circuit, are installed in parallel. Where multi-core cables are installed in parallel, each cable shall contain one conductor of each phase and the neutral if any.

13.4.2 External ducts

Conductors and their connections external to the electrical equipment enclosure(s) shall be enclosed in suitable ducts (i.e. conduit or cable trunking systems) as described in 13.5 except for suitably protected cables that may be installed without ducts and with or without the use of open cable trays or cable support means. Where devices such as position switches or proximity switches are supplied with a dedicated cable, their cable need not be enclosed in a duct when the cable is suitable for the purpose, sufficiently short, and so located or protected, that the risk of damage is minimized.

Fittings used with ducts or cables shall be suitable for the physical environment.

Flexible conduit or flexible multi-conductor cable shall be used where it is necessary to employ flexible connections to pendant push-button stations. The weight of the pendant stations shall be supported by means other than the flexible conduit or the flexible multi-conductor cable, except where the conduit or cable is specifically designed for that purpose.

Flexible conduit or flexible multi-conductor cable shall be used for connections involving small or infrequent movements. They shall also be permitted to complete the connection to normally stationary motors, to position switches and to other externally mounted devices.

13.4.3 Connection to the hoisting machine and to moving elements on the hoisting machine

The design of connections to moving parts shall take into account the foreseeable frequency of movement and shall be made using conductors in accordance with 12.2 and 12.6. Flexible cable and flexible conduit shall be so installed as to avoid excessive flexing and straining, particularly at the fittings.

Cables subject to movement shall be supported in such a way that there is no mechanical strain on the connection points nor any sharp flexing. When this is achieved by the provision of a loop, it shall have sufficient length to provide for a bending radius of the cable as specified by the cable manufacturer or, if no such specification is given, at least 10 times the diameter of the cable.

Flexible cables of hoisting machines shall be so installed or protected as to minimize the possibility of external damage due to factors that include the following cable use or potential abuse:

- being run over by the hoisting machine itself;
- being run over by other machines or vehicles;
- coming into contact with the hoisting machine structure during movements;
- running in and out of cable baskets, or on or off cable drums;
- acceleration forces and wind forces on festoon systems or suspended cables;
- misalignment of energy chain systems;

- excessive rubbing by cable collector;
- exposure to excessive radiated heat.

The cable sheath shall be resistant to the normal wear that can be expected from movement and to the effects of environmental contaminants (e.g. oil, water, coolants, dust).

Where cables subject to movement are close to moving parts, precautions shall be taken to maintain a space of at least 25 mm between the moving parts and the cables. Where that distance is not practicable, fixed barriers shall be provided between the cables and the moving parts.

The cable handling system shall be so designed that lateral cable angles do not exceed 5°, avoiding torsion in the cable when

- being wound on and off cable drums, and
- approaching and leaving cable guidance devices.

Measures shall be taken to ensure that at least two turns of flexible cables always remain on a drum.

Devices serving to guide and carry a flexible cable shall be so designed that the inner bending radius at all points where the cable is bent is not less than the values given in Table 9, unless otherwise agreed with the cable manufacturer, taking into account the permissible tension and the expected fatigue life.

Table 9 – Minimum permitted bending radii for the forced guiding of flexible cables

Application	Cable diameter or thickness of flat cable (d)		
	mm		
	$d \leq 8$	$8 < d \leq 20$	$d > 20$
Cable drums	$6 d$	$6 d$	$8 d$
Guide rollers	$6 d$	$8 d$	$8 d$
Festoon systems	$6 d$	$6 d$	$8 d$
All others	$6 d$	$6 d$	$8 d$

The straight section between two bends shall be at least 20 times the diameter of the cable. Where flexible conduit is adjacent to moving parts, the construction and supporting means shall prevent damage to the flexible conduit under all conditions of operation.

Flexible conduit shall not be used for connections subject to rapid or frequent movements except when specifically designed for that purpose.

13.4.4 Interconnection of devices on the hoisting machine

Where several hoisting machine-mounted devices (e.g. position sensors, push-buttons) are connected in series or in parallel, it is recommended that the connections between those devices be made through terminals forming intermediate test points. Such terminals shall be conveniently placed, adequately protected, and shown on the relevant diagrams.

13.4.5 Plug/socket combinations

Components or devices inside an enclosure, terminated by fixed plug/socket combinations (no flexible cable), or components connected to a bus system by a plug/socket combination, are not considered to be plug/socket combinations for the purpose of 13.4.5.

Where plug/socket combinations are provided, they shall fulfil one or more of the following requirements as applicable.

- a) When installed correctly in accordance with f), plug/socket combinations shall be of such a type as to prevent unintentional contact with live parts at any time, including during insertion or removal of the connectors. The degree of protection shall be at least IPXXB. PELV and SELV circuits are excepted from this requirement.
- b) Plug/socket combinations shall have a first-make last-break protective bonding contact (earthing contact) (see also 6.3, 8.2.4) if used in TN- or TT-systems.
- c) Plug/socket combinations intended to be connected or disconnected during load conditions shall have sufficient load-breaking capacity. Where such a plug/socket combination is rated at 32 A, or greater, it shall be interlocked with a switching device so that the connection and disconnection is possible only when the switching device is in the OFF position.
- d) Plug/socket combinations that are rated at more than 16 A shall have a retaining means to prevent unintended or accidental disconnection.
- e) Where an unintended or accidental disconnection of plug/socket combinations can cause a hazardous situation, they shall have a retaining means.

The installation of plug/socket combinations shall fulfil the following requirements as applicable.

- f) The component which remains live after disconnection shall have a degree of protection of at least IP2X or IPXXB, taking into account the required clearance and creepage distances. PELV and SELV circuits are excepted from this requirement.
- g) Metallic housings of plug/socket combinations shall be connected to the protective bonding circuit. PELV and SELV circuits are excepted from this requirement.
- h) Plug/socket combinations intended to carry power loads but not to be disconnected during load conditions shall have a retaining means to prevent unintended or accidental disconnection and it shall be clearly marked that they are not intended to be disconnected under load.
- i) Where more than one plug/socket combination is provided in the same electrical equipment, the associated combinations shall be clearly identifiable. It is recommended that mechanical coding be used to prevent incorrect insertion.
- j) Plug/socket combinations used in control circuits shall fulfil the applicable requirements of IEC 61984.

Exception: In plug/socket combinations in accordance with IEC 60309-1, only those contacts shall be used for control circuits which are intended for those purposes. This exception does not apply to control circuits using high frequency signals superimposed on the power circuits.

13.4.6 Dismantling for shipment

Where it is necessary that wiring is disconnected for shipment, terminals or plug/socket combinations shall be provided at the sectional points. Such terminals shall be suitably enclosed and plug/socket combinations shall be protected from the physical environment during transportation and storage.

13.4.7 Additional conductors

Consideration should be given to providing additional conductors for maintenance or repair. When spare conductors are provided, they shall be connected to spare terminals or isolated in such a manner as to prevent contact with live parts.

13.5 Ducts, connection boxes and other boxes

13.5.1 General requirements

Ducts shall provide a degree of protection (see IEC 60529) suitable for the application.

All sharp edges, flash, burrs, rough surfaces, or threads with which the insulation of the conductors can come in contact shall be removed from ducts and fittings. Where necessary, additional protection consisting of a flame-retardant, oil-resistant insulating material shall be provided to protect conductor insulation.

Drain holes of 6 mm diameter are permitted in cable trunking systems, connection boxes, and other boxes used for wiring purposes that can be subject to accumulations of oil or moisture.

In order to prevent confusion of conduits with oil, air, or water piping, it is recommended that the conduits be either physically separated or suitably identified.

Ducts and cable trays shall be rigidly supported and positioned at a sufficient distance from moving parts and in such a manner so as to minimize the possibility of damage or wear. In areas where human passage is required, the ducts and cable trays shall be mounted to give at least the clearance specified in 11.5.

Cable trays that are partially covered should not be considered to be ducts or cable trunking systems (see 13.5.6), and the cables used shall be of a type suitable for installation on open cable trays.

13.5.2 Percentage fill of ducts

Consideration of the percentage fill of ducts should be based on the straightness and length of the duct and the flexibility of the conductors. It is recommended that the dimensions and arrangement of the ducts be such as to facilitate the insertion of the conductors and cables.

13.5.3 Rigid metal conduits and fittings

Rigid metal conduit and fittings shall be of galvanized steel or of a corrosion-resistant material suitable for the conditions. Where galvanic action is possible between dissimilar metals, these metal combinations shall not be used.

Conduits shall be securely held in place and supported at each end.

Fittings shall be compatible with the conduit and appropriate for the application. Fittings should be threaded unless structural difficulties prevent assembly. Where threadless fittings are used, the conduit shall be securely fastened to the equipment.

Conduit bends shall be made in such a manner that the conduit shall not be damaged and the internal diameter of the conduit shall not be effectively reduced.

13.5.4 Flexible metal conduits and fittings

A flexible metal conduit shall consist of a flexible metal tubing or woven wire armour. It shall be suitable for the expected physical environment.

Fittings shall be compatible with the conduit and appropriate for the application.

13.5.5 Flexible non-metallic conduits and fittings

Flexible non-metallic conduit shall be resistant to kinking and shall have physical characteristics similar to those of the sheath of multi-conductor cables.

The conduit shall be suitable for use in the expected physical environment.

Fittings shall be compatible with the conduit and appropriate for the application.

13.5.6 Cable trunking systems

Cable trunking systems external to enclosures shall be rigidly supported and clear of all moving parts of the hoisting machine and of sources of contamination.

Covers shall be shaped to overlap the sides; gaskets are permitted. Covers shall be attached to cable trunking systems by suitable means. On horizontal cable trunking systems, the cover shall not be on the bottom unless specifically designed for such installation.

NOTE Requirements for cable trunking and ducting systems for electrical installations are given in IEC 61084 (all parts).

Where the cable trunking system is furnished in sections, the joints between sections shall fit tightly but need not be gasketed.

The only openings permitted shall be those required for wiring or for drainage. Cable trunking systems shall not have opened but unused knockouts.

13.5.7 Hoisting machine compartments and cable trunking systems

Compartments or cable trunking systems may be used within a hoisting machine to enclose conductors provided that the compartments or cable trunking systems are isolated from coolant or oil reservoirs and are entirely enclosed. Conductors run in enclosed compartments and cable trunking systems shall be so secured and arranged that they are not subject to damage.

13.5.8 Connection boxes and other boxes

Connection boxes and other boxes used for wiring purposes shall be accessible for maintenance. Those boxes shall provide protection against the ingress of solid bodies and liquids, taking into account the external influences under which the hoisting machine is intended to operate (see 11.3). The construction shall be sufficient to protect against mechanical damage in normal use.

Those boxes shall not have unused openings and they shall provide adequate protection against materials such as dust, flyings, oil, and coolant.

13.5.9 Motor connection boxes

Motor connection boxes shall enclose only connections to the motor and motor-mounted devices (e.g. brakes, temperature sensors, plugging switches, tachometer generators).

14 Electric motors and associated equipment

14.1 General requirements

Electric motors should conform to the relevant parts of IEC 60034 series.

The protection requirements for motors and associated equipment are given in 7.2 for overcurrent protection, in 7.3 for protection against overheating, and in 7.6 for overspeed protection.

As many controllers do not switch off the supply to a motor when it is at rest, compliance with the requirements of 5.3, 5.4, 5.5, 7.5, 7.6 and 9.4 shall be ensured. Motor control equipment shall be located and mounted in accordance with Clause 11.

14.2 Motor enclosures

Enclosures for motors should be in accordance with IEC 60034-5.

The degree of protection shall be dependent on the application and the physical environment (see 4.4).

All motors shall be adequately protected from mechanical damage.

14.3 Motor dimensions

As far as is practicable, the dimensions of motors shall conform to those given in IEC 60072-1, IEC 60072-2 or IEC 60072-3, as applicable.

14.4 Motor mounting and compartments

Each motor and its associated couplings, belts, pulleys or chains shall be mounted so that they are adequately protected and easily accessible for inspection, maintenance, adjustment and alignment, lubrication, and replacement. The motor mounting arrangement shall be such that all motor mounting means can be removed and all terminal boxes are accessible.

Motors shall be so mounted that proper cooling is ensured and the temperature rise remains within the limits of the insulation class (see IEC 60034-1:2017).

Where practicable, motor compartments should be clean and dry, and when required, shall be ventilated directly to the exterior of the hoisting machine. The vents shall be such that ingress of swarf, dust or water spray is at an acceptable level.

There shall be no opening between the motor compartment and any other compartment that does not meet the motor compartment requirements. Where a conduit or pipe is run into the motor compartment from another compartment not meeting the motor compartment requirements, any clearance around the conduit or pipe shall be sealed.

14.5 Criteria for motor selection

The characteristics of motors and associated equipment shall be selected in accordance with the anticipated service and physical environmental conditions (see Annex B and 4.4). In this respect, the points that shall be considered include

- type of motor;
- type of duty cycle (see IEC 60034-1:2017);
- expected frequency of starting;
- fixed speed or variable speed operation (and the consequent variable influence of the ventilation);
- mechanical vibration;
- type of motor control;
- temperature rise and other effects of the frequency spectrum of the voltage and/or current feeding the motor (particularly when it is supplied from a converter);
- method of starting and the possible influence of the inrush current on the operation of other users of the same power supply, taking also into account possible special considerations stipulated by the supply authority;
- variation of counter-torque load with time and speed;
- influence of loads with large inertia;
- influence of constant torque or constant power operation;
- possible need of inductive reactors between motor and converter.

14.6 Protective devices for mechanical brakes

Operation of the overload and overcurrent protective devices for mechanical brake actuators shall initiate the simultaneous de-energization (release) of the associated hoisting machine actuators.

NOTE Associated hoisting machine actuators are those associated with the same motion, for example, cable drums and long-travel drives.

14.7 Electrically operated mechanical brakes

Where electrically operated mechanical brakes which are applied by removal of power are used, removal of power to motion drives shall result in removal of power to the associated brakes.

Exception: Operational braking in travel and slewing drives may use other methods of brake control.

15 Socket-outlets and lighting

15.1 Socket-outlets for accessories

Where the hoisting machine or its associated equipment is provided with socket-outlets that are intended to be used for accessory equipment (e.g. hand-held power tools, test equipment), the following apply.

- The socket-outlets should conform to IEC 60309-1. Where that is not practicable, they should be clearly marked with the voltage and current ratings.
- The socket outlet shall include a protective bonding connection except where protection is provided by PELV.

NOTE Where it is necessary for operational purposes for some equipment to be isolated from the protective bonding circuit, such socket-outlets can be excluded from this requirement.

- All unearthed conductors connected to the socket-outlet shall be protected against overcurrent and, when required, against overload in accordance with 7.2 and 7.3 separately from the protection of other circuits.
- Where the power supply to the socket-outlet is not disconnected by the crane-disconnector, the requirements of 5.3.8 apply.
- In circuits for socket outlets with a current rating not exceeding 32 A and accessible from outside the enclosure or enclosed electrical operating area, fault protection by automatic disconnection (see 6.3.3, measure a) is not sufficient without additional protective measures (e.g. RCDs with a rated residual operating current not exceeding 30 mA).

15.2 Local lighting of the hoisting machine and of the equipment

15.2.1 General

Connections to the protective bonding circuit shall be in accordance with 8.2.2.

The ON-OFF switch shall not be incorporated in the lamp holder or in the flexible connecting cords.

Stroboscopic effects from lights shall be avoided by the selection of appropriate luminaires.

15.2.2 Supply

The nominal voltage of the local lighting circuit shall not exceed 250 V between conductors. A voltage not exceeding 50 V between conductors is recommended.

Lighting circuits shall be supplied from one of the following sources (see also 7.2.6):

- a dedicated isolating transformer connected to the load side of the crane-disconnector. Overcurrent protection shall be provided in the secondary circuit;
- a dedicated isolating transformer connected to the line side of the crane-disconnector. That source shall be permitted for maintenance lighting circuits in control enclosures only. Overcurrent protection shall be provided in the secondary circuit (see also 5.3.8);
- a circuit of the electrical equipment of the hoisting machine for lighting with dedicated overcurrent protection;
- an isolating transformer connected to the line side of the supply disconnecting device, provided with a dedicated primary disconnecting means (see 5.3.5) and secondary overcurrent protection, and mounted within the control enclosure adjacent to the supply disconnecting device;
- an externally supplied lighting circuit (e.g. factory lighting supply). This shall be permitted in control enclosures only, and for the hoisting machine work light(s) where their total power rating is not more than 3 kW;
- power supply units, for DC supply to LED light sources, fitted with isolating transformers (for example, in accordance with IEC 61558-2-6).

Exception: Where fixed lighting is out of reach of operators during normal operations, the provisions of 15.2.2 do not apply.

15.2.3 Protection

Local lighting circuits shall be protected in accordance with 7.2.6.

15.2.4 Fittings

Adjustable lighting fittings shall be suitable for the physical environment.

The lampholders shall be

- in accordance with the relevant IEC standard;
- constructed with an insulating material protecting the lamp cap so as to prevent unintentional contact.

Reflectors shall be supported by a bracket and not by the lampholder.

Exception: Where fixed lighting is out of reach of operators during normal operation, the provisions of 15.2.4 do not apply.

16 Marking, warning signs and reference designations

16.1 General

Warning signs, nameplates, markings, labels and identification plates shall be of sufficient durability to withstand the physical environment involved.

16.2 Warning signs

16.2.1 Electric shock hazard

Enclosures that do not otherwise clearly show that they contain electrical equipment that can give rise to a risk of electric shock shall be marked with the graphical symbol ISO 7010-W012 (2011-05) (see Figure 23).



Figure 23 – Symbol ISO 7010-W012

The warning sign shall be plainly visible on the enclosure door or cover.

The warning sign may be omitted (see also 6.2.2 b)) for

- an enclosure equipped with the crane-supply-switch and the crane-disconnector;
- an operator-machine interface or control station;
- a single device with its own enclosure (e.g. position sensor).

16.2.2 Hot surfaces hazard

Where the risk assessment shows the need to warn against the possibility of hazardous surface temperatures of the electrical equipment, the graphical symbol ISO 7010-W017 (2011-05) shall be used (see Figure 24).



Figure 24 – Symbol ISO 7010-W017

NOTE ISO 13732-1 gives guidance for the assessment of the risks of burns when humans touch hot surfaces with their unprotected skin.

16.2.3 Hazard from energy storage system

Where the equipment includes an energy storage system (battery, super capacitor, etc.) and hazardous voltages may be present after disconnection of power supply, a durable warning sign shall be provided. Figure 25 shows a suitable warning sign that includes graphical symbols ISO 7010-W001 (2011-05) and ISO 7010-W012 (2011-05).



IEC

Figure 25 – Warning sign: energy storage system

16.3 Functional identification

Control devices and visual indicators shall be clearly and durably marked with regard to their functions either on, or adjacent to the item. Such markings may be as agreed between the user and the supplier of the equipment. It is recommended that such markings are in accordance with IEC 60417 and ISO 7000.

16.4 Marking of enclosures of electrical equipment

The following information shall be legibly and durably marked in a way that is plainly visible after the equipment is installed on enclosures that receive external incoming power supplies:

- name or trade mark of supplier;
- type designation or model, where applicable;
- serial number, where applicable;
- main document number (see IEC 62023), where applicable;
- rated voltage, number of phases and frequency (if AC), and rated current for each incoming supply.

It is recommended that this information is provided adjacent to the main incoming supply or supplies.

Where only a single motor controller is used, that information may instead be provided on the hoisting machine nameplate where it is plainly visible. For a hoisting machine with more than one motion drive, such nameplates may be replaced by the relevant documentation.

Exception: Other enclosures of the same electrical equipment that are connected to a main switchgear or to other panels shall bear at least the following information:

- name or trade mark of supplier;
- type designation or designation reference according the documentation provided (electrical drawings or schematics);
- serial number, where applicable and if not already included in the designation reference.

16.5 Reference designations

All enclosures, assemblies, control devices, and components shall be plainly identified with the same reference designation as shown in the technical documentation.

Exception: Hoisting machines, on which the equipment comprises only a single motor, motor-controller, push-button station(s) and work light(s), need not conform to 16.5.

17 Technical documentation

17.1 General

The information necessary for installation, operation, and maintenance of the electrical equipment of a hoisting machine shall be supplied in the appropriate forms, for example, drawings, diagrams, charts, tables, instructions. The information shall be in an agreed language (see also Annex B).

NOTE 1 Documentation is sometimes supplied in paper form, since it cannot be assumed that the user has access to the means of reading instructions supplied in electronic form or made available on an Internet site. However, it is often useful for the documentation to be made available in electronic form and on the Internet as well as in paper form, since this enables the user to download the electronic file and to recover the documentation if the paper copy has been lost. This practice also facilitates the updating of the documentation when this is necessary.

NOTE 2 In some countries, the requirement to use specific language(s) is covered by legal requirements.

Annex H should be considered as guidance for the preparation of information and documents.

17.2 Information related to the electrical equipment

The following shall be supplied:

- a) where more than one document is provided, a main document for the electrical equipment as a whole, listing the complementary documents associated with the electrical equipment;
- b) identification of the electrical equipment (see 16.4);
- c) information on installation and mounting including:
 - a description of the electrical equipment's installation and mounting, and its connection to the electrical supplies and where relevant other supplies;
 - short-circuit current rating of the electrical equipment for each incoming power supply;
 - rated voltage, number of phases and frequency (if AC), type of distribution system (TT, TN, IT) and full-load current for each incoming supply;
 - any additional electrical supply requirements (for example maximum supply source impedance, leakage current) for each incoming supply;
 - space required for the removal or servicing of the electrical equipment;
 - installation requirements where needed to ensure that the arrangements for cooling are not impaired;
 - environmental limitations (for example lighting, vibration, EMC environment, atmospheric contaminants) where appropriate;
 - functional limitations (for example peak starting currents and permitted voltage drop(s)) as applicable;
 - precautions to be taken for the installation of the electrical equipment relevant to the electromagnetic compatibility;
- d) an instruction for the connection of simultaneously accessible extraneous conductive parts in the vicinity of the machine (for example, within 2,5 metres) such as the following to the protective bonding circuit:
 - metallic pipes;
 - fences;
 - ladders;
 - handrails.
- e) information on the functioning and operation, including as applicable:
 - an overview of the structure of the electrical equipment (for example by structure diagram or overview diagram);
 - procedures for programming or configuring, as necessary for the intended use;
 - procedures for restarting after an unexpected stop;
 - a sequence of operation;
- f) information on maintenance and periodic tests of the electrical equipment, as appropriate, including:
 - frequency and method of functional testing and measurements;
 - instructions on the procedures for safe maintenance and where it is necessary to suspend a safety function and/or protective measure (see 9.2.4);
 - guidance on the adjustment, repair, and frequency and method of preventive maintenance;
 - details of the interconnections of the electrical components subject to replacement (for example by circuit diagrams and/or connection tables);
 - information on required special devices or tools;

- information on spare parts;
 - information on possible residual risks, indication of whether any particular training is required and specification of any necessary personal protective equipment;
 - where applicable, instructions to restrict availability of key(s) or tool(s) to skilled or instructed persons only;
 - settings (DIP-switches, programmable parameter values, etc);
 - information for validation of safety related control functions after repair or modification, and for periodic testing where necessary;
- g) information on handling, transportation and storage as appropriate (for example dimensions, weight, environmental conditions, possible ageing constraints);
- h) information for proper disassembly and handling of components (for example for recycling or disposal).

18 Verification

18.1 General

Clause 18 gives general requirements for the verification of the electrical equipment of hoisting machines.

The extent of verification for a particular hoisting machine type will be given in the dedicated product standard. Where there is no dedicated product standard for the machine, the verifications shall always include the items a), b), c), d) and h) and may include one or more of the items e) to g):

- a) verification that the electrical equipment complies with its technical documentation;
- b) verification of continuity of the protective bonding circuit (Test 1 of 18.2.2);
- c) in case of fault protection by automatic disconnection of supply, verification of the conditions for protection by automatic disconnection (see 18.2);
- d) insulation resistance test (see 18.3);
- e) voltage test (see 18.4);
- f) protection against residual voltage (see 18.5);
- g) verification that the relevant requirements of 8.2.8 are met;
- h) functional tests (see 18.6).

When these tests are performed, it is recommended that they follow the sequence listed above. Where the sequence cannot be followed, verification a) and b) shall be conducted first.

When the electrical equipment is modified, the requirements specified in 18.7 shall apply.

For verifications that include measurement, measuring equipment in accordance with IEC 61557 (all parts) is recommended.

The results of the verification shall be documented.

18.2 Verification of conditions for protection by automatic disconnection of supply

18.2.1 General

The conditions for automatic disconnection of supply (see 6.3.3) shall be verified by tests.

Test 1 verifies the continuity of the protective bonding circuit.

Test 2 verifies the conditions for protection by automatic disconnection of the supply in TN systems.

For TN-systems, those test methods are described in 18.2.2 and 18.2.3; their application for different conditions of supply are specified in 18.2.4.

For TT systems, see Clause A.2.

IT systems, see IEC 60364-6:2016.

Where RCDs are used in the electrical equipment, their function shall be verified in accordance with the manufacturer's instructions. The test procedure and test interval shall be specified in the maintenance instructions.

18.2.2 Test 1 – Verification of the continuity of the protective bonding circuit

The resistance between the PE terminal (see 5.2 and Figure 4) and relevant points that are part of the protective bonding circuit shall be measured with a current between at least 0,2 A and approximately 10 A derived from an electrically separated supply source (for example SELV, see Clause 414 of IEC 60364-4-41:2005) having a maximum no-load voltage of 24 V AC or DC.

The resistance measured shall be in the expected range according to the length, the cross-sectional area and the material of the related protective conductors and protective bonding conductor(s).

Earthed PELV supplies can produce misleading results in this test and therefore shall not be used.

NOTE Larger currents used for the continuity test increase the accuracy of the test result, especially with low resistance values, i.e. larger cross-sectional areas and/or lower conductor lengths.

18.2.3 Test 2 – Fault loop impedance verification and suitability of the associated overcurrent protective device

The connections of each power supply including the connection of the associated external protective conductor to the PE terminal of the hoisting machine, shall be verified by inspection.

The conditions for the protection by automatic disconnection of supply in accordance with 6.3.3 and Annex A shall be verified by both

- a) verification of the fault loop impedance by
 - calculation, or
 - measurement in accordance with A.1.4, or A.2.4 for TT-systems; and
- b) confirmation that the setting and characteristics of the associated overcurrent protective device are in accordance with the requirements of Annex A and where a power drive system (PDS) is used, confirmation that the setting and characteristics of the protective device(s) associated with a PDS are in accordance with the converter manufacturer's and protective device manufacturer's instructions.

NOTE Fault loop impedance can be measured for circuits where the conditions of protection by automatic disconnection require a current I_a up to about 1 kA (I_a is the current causing the automatic operation of the disconnecting device within the time specified in Annex A).

18.2.4 Application of the test methods for TN-systems

Each protective bonding circuit of a hoisting machine shall be tested in accordance with Test 1 of 18.2.2.

When Test 2 of 18.2.3 is carried out by measurement, it shall always be preceded by Test 1.

NOTE A discontinuity of the protective bonding circuit can cause a hazardous situation for the tester or other persons, or damage to the electrical equipment during the loop impedance test.

The tests that are necessary for hoisting machines of different status are specified in Table 10.

Table 10 – Application of the test methods for TN-systems

Procedure	Machine status	Verification on site
A	Electrical equipment of machines, erected and connected on site, where the continuity of the protective bonding circuits has not been confirmed following erection and connection on site.	Test 1 (see 18.2.2) and Test 2 (see 18.2.3) Exception: Test 2 is not required where: • test 1 is performed on the protective bonding conductors of the machine that are connected on site; and • the connections of each incoming power supply and of the associated protective conductor (PE) to the PE-terminal of the machine, are verified by inspection, and previous calculations of the fault loop impedance (or resistance) by the manufacturer of the electrical equipment are available; and • the arrangement of the installations permits the verification of the length and cross-sectional area of the conductors used for the calculation; and • it can be confirmed through calculation or measurement, or by information supplied by the customer, that the supply source impedance on site does not exceed the value specified by the manufacturer of the electrical equipment. See 17.2 c), fourth bullet).
B	Machine supplied with confirmation of the verification (see 18.1) of continuity of the protective bonding circuits by test 1 or with the results of a test 2 by measurement, having protective bonding circuits exceeding the cable length for which examples are given in Table 9.	Test 2 (see 18.2.3) Exception: Where it can be confirmed through calculation or measurement, or by information supplied by the customer, that the supply source impedance on site does not exceed the value specified by the manufacturer of the electrical equipment, or that of the test supply during a test 2 by measurement, no test is required on site apart from verification of the connections:
	Case B1) supplied fully assembled and not dismantled for shipment,	in case B1) of each incoming power supply and of the associated protective conductor to the PE terminal of the machine;
	Case B2) supplied dismantled for shipment, where the continuity of protective conductors is ensured after dismantling, transportation and reassembly (for example by the use of plug/socket connections).	in case B2) of each incoming power supply and of the associated protective conductor to the PE terminal of the machine and of all connections of the protective conductor(s) that were disconnected for shipment.
C	Machine having protective bonding circuits not exceeding the cable length for which examples are given in Table 10, supplied with confirmation of the verification (see 18.1) of continuity of the protective bonding circuits by test 1.	For case C1 or C2, no test is required on site. For a machine not connected to the power supply by a plug/socket combination, the correct connection of the external protective conductor to the PE-terminal of the machine shall be verified by visual inspection.
	Case C1) supplied fully assembled and not dismantled for shipment.	
	Case C2) supplied dismantled for shipment, where the continuity of protective conductors is ensured after dismantling, transportation and reassembly (for example by the use of plug/socket combination(s)).	In case C2), the installation documents (see 17.2) shall require that all connections of the protective conductor(s) that were disconnected for shipment are verified, for example by visual inspection.

Examples of maximum cable length from each protective device to their loads for TN-systems are shown in Table 11.

Table 11 – Examples of maximum cable length from each protective device to their loads for TN-systems

1 Maximum source impedance of the supply to the protective device	2 Minimum cross-sectional area	3 Maximum nominal rating or setting of the protective device I_N	4 Fuse disconnect time 5 s	5 Fuse disconnect time 0,4 s	6 Miniature circuit-breaker char.B $I_a = 5 \times I_N$	7 Miniature circuit-breaker char.C $I_a = 10 \times I_N$	8 Miniature circuit-breaker char.D $I_a = 20 \times I_N$	9 Adjustable circuit-breaker $I_a = 8 \times I_N$
mΩ	mm ²	A	Maximum cable length in metres from each protective device to its load					
500	1,5	16	97	53	76	30	7	31
500	2,5	20	115	57	94	34	3	36
500	4,0	25	135	66	114	35		38
400	6,0	32	145	59	133	40		42
300	10	50	125	41	132	33		37
200	16	63	175	73	179	55		61
200	25 (line)/ 16 (PE)	80	133					38
100	35 (line)/ 16 (PE)	100	136					73
100	50 (line)/ 25 (PE)	125	141					66
100	70 (line)/ 35 (PE)	160	138					46
50	95 (line)/ 50 (PE)	200	152					98
50	120 (line)/ 70 (PE)	250	157					79

The values of the maximum cable length in Table 11 are based on the following assumptions:

- PVC cable with copper conductors, conductor temperature under short-circuit conditions 160 °C (see Table C.5);
- cables with line conductors up to 16 mm² provide a protective conductor of equal cross sectional area to that of the line conductors;
- cables above 16 mm² provide a reduced size protective conductor as shown;
- 3-phase system, nominal voltage of the power supply 400 V ($U_0 = 230$ V);
- column 3 values are correlated with Table 7 (see 12.4);
- disconnection time for circuit-breakers is $\leq 0,4$ s (columns 6 to 9).

NOTE A deviation from these assumptions can require a complete calculation or measurement of the fault loop impedance. Further information is available from IEC 60228 and IEC TS 61200-53.

18.3 Insulation resistance tests

When insulation resistance tests are performed, the insulation resistance measured at 500 V DC between the power circuit conductors and the protective bonding circuit shall be not less than 1 MΩ. The test may be made on individual sections of the complete electrical installation.

Exception: For certain parts of electrical equipment, incorporating, for example, busbars, conductor wire or conductor bar systems or slip-ring assemblies, a lower minimum value is permitted, but that value shall not be less than 50 kΩ.

If the electrical equipment of the hoisting machine contains surge protection devices which are likely to operate during the test, it is permitted to either

- disconnect these devices; or
- reduce the test voltage to a value lower than the voltage protection level of the surge protection devices, but not lower than the peak value of the upper limit of the supply (phase-to-neutral) voltage.

18.4 Voltage tests

The test voltage shall be at a nominal frequency of 50 Hz or 60 Hz.

The maximum test voltage shall have a value of twice the rated supply voltage of the equipment or 1 000 V, whichever is the greater. The maximum test voltage shall be applied between the power circuit conductors and the protective bonding circuit for at least 1 s. The requirements are satisfied if no disruptive discharge occurs.

Components and devices that are not rated to withstand the test voltage and surge protection devices which are likely to operate during the test shall be disconnected before testing.

Components and devices that have been voltage tested in accordance with their product standards may be disconnected during testing.

NOTE Test equipment in accordance with IEC 61180 or IEC 61557-14 can be used to perform voltage testing.

18.5 Protection against residual voltages

Where appropriate, tests shall be performed to ensure compliance with 6.2.4.

18.6 Functional tests

The functions of electrical equipment shall be tested, particularly those related to safety and safeguarding. Where a function cannot be fully tested, the circuit(s) shall be tested.

18.7 Retesting

Where a portion of the hoisting machine and its associated equipment is changed or modified, the need for re-verification and testing of the electrical equipment shall be considered.

Particular attention should be given to the possible adverse effects that retesting can have on the equipment (e.g. overstressing of insulation, disconnection/reconnection of devices).

Annex A (normative)

Fault protection by automatic disconnection of supply

A.1 Fault protection for machines supplied from TN-systems

A.1.1 General

The provisions in Annex A are derived from IEC 60364-4-41:2005, IEC 60364-4-41:2005/AMD1:2017, and IEC 60364-6:2016.

Fault protection shall be provided by an overcurrent protective device that automatically disconnects the supply to the circuit or equipment in the event of a fault between a live part and an exposed conductive part or a protective conductor in the circuit or equipment, within a sufficiently short disconnecting time. A disconnecting time not exceeding 5 s is considered sufficiently short for machines that are neither hand-held nor portable.

Where this disconnecting time cannot be assured, supplementary protective bonding shall be provided in accordance with A.1.3 that can prevent a prospective touch voltage from exceeding 50 V AC or 120 V ripple-free DC between simultaneously accessible conductive parts.

NOTE The use of supplementary protective bonding does not preclude the need to disconnect the supply for other reasons, for example protection against fire, thermal stresses in equipment, etc.

For circuits which supply, through socket-outlets or directly without socket-outlets, Class 1 hand-held equipment or portable equipment (for example socket-outlets on a machine for accessory equipment, see 15.1) Table A.1 specifies the maximum disconnecting times that are considered sufficiently short.

Table A.1 – Maximum disconnecting times for TN systems

System	Maximum disconnecting time							
	s							
	50 V < $U_0 \leq 120$ V		120 V < $U_0 \leq 230$ V		230 V < $U_0 \leq 400$ V		$U_0 > 400$ V	
	AC	DC	AC	DC	AC	DC	AC	DC
TN	0,8	NOTE 1	0,4	5	0,2	0,4	0,1	0,1
U_0 is the nominal AC or DC line-to-earth voltage.								
NOTE 1 Disconnection can be required for reasons other than protection against electric shock.								
NOTE 2 For voltages which are within the tolerance band stated in IEC 60038, the disconnecting time appropriate to the nominal voltage applies.								

A.1.2 Conditions for protection by automatic disconnection of the supply by overcurrent protective devices

The characteristics of overcurrent protective devices and the circuit impedances shall be such that, if a fault of negligible impedance occurs anywhere in the electrical equipment between a line conductor and a protective conductor or exposed conductive part, automatic disconnection of the supply will occur within the specified time (i.e. ≤ 5 s or less than or equal to the values in accordance with Table A.1). The following general condition fulfils this requirement:

$$Z_s \times I_a \leq U_0$$

where

Z_s is the impedance of the fault loop comprising the source, the live conductor up to the point of the fault and the protective conductor between the point of the fault and the source;

I_a is the current causing the automatic operation of the disconnecting protective device within the specified time;

U_0 is the nominal AC voltage to earth.

The increase of the resistance of the conductors with the increase of temperature due to the fault current shall be taken into account in the following equation:

$$Z_{s(n)} \leq \frac{2}{3} \times \frac{U_0}{I_a}$$

where $Z_{s(n)}$ is the measured or calculated value of Z_s under normal operating conditions.

NOTE Where the value of the fault loop impedance exceeds $2U_0/3I_a$, a more precise assessment can be made in accordance with the procedure described in D.6.4.3.7.3 of IEC 60364-6:2016.

A.1.3 Condition for protection by reducing the touch voltage below 50 V

Where the requirements of A.1.2 cannot be assured, supplementary protective bonding can be selected as the means of ensuring that touch voltages will not exceed 50 V. This is achieved when the impedance of the protective bonding circuit (Z_{PE}) does not exceed:

$$Z_{PE} \leq \frac{50}{U_0} \times Z_s$$

where Z_{PE} is the impedance of the protective bonding circuit between the equipment anywhere in the installation and the PE terminal of the machine (see 5.2 and Figure 6) or between simultaneously accessible exposed conductive parts and/or extraneous conductive parts.

Confirmation of this condition can be achieved by using the method of Test 1 of 18.2.2 to measure the resistance R_{PE} . The condition for protection is achieved when the measured value of R_{PE} does not exceed:

$$R_{PE} \leq \frac{50}{I_{a(5s)}}$$

where

$I_{a(5s)}$ is the 5 s operating current of the protective device;

R_{PE} is the resistance of the protective bonding circuit between the PE terminal (see 5.2 and Figure 6) and the equipment anywhere on the machine, or between simultaneously accessible exposed conductive parts and/or extraneous conductive parts.

NOTE 1 Supplementary protective bonding is considered as an addition to fault protection.

NOTE 2 Supplementary protective bonding can involve the entire installation, a part of the installation, an item of apparatus, or a location.

A.1.4 Verification of conditions for protection by automatic disconnection of the supply

A.1.4.1 General

The effectiveness of the measures for fault protection by automatic disconnection of supply in accordance with A.1.2 is verified as follows:

- verification of the characteristics of the associated protective device by visual inspection of the nominal current setting for circuit-breakers and the current rating for fuses; and
- measurement of the fault loop impedance (Z_s). See Figure A.1.

Exception: Verification of the continuity of the protective conductors may replace the measurement where the calculations of the fault loop impedance are available and when the arrangement of the installations permits the verification of the length and cross-sectional area of the conductors.

Where a power drive system (PDS) is used, the disconnection time for fault protection shall meet the relevant requirements of this Annex A at the incoming supply terminals of the basic drive module (BDM) of the PDS. See Figure A.2.

A.1.4.2 Measurement of the fault loop impedance

Where measurement of the fault loop impedance is performed, it is recommended that the measuring equipment comply with IEC 61557-3. The information about the accuracy of the measuring results, and the procedures to be followed given in the documentation of the measuring equipment shall be considered.

Measurement shall be performed when the machine is connected to a supply having the same frequency as the nominal frequency of the supply at the intended installation.

NOTE Figure A.1 illustrates a typical arrangement for measuring the fault loop impedance on a machine.

If it is not practicable for the motor to be connected during the test, the two line conductors not used in the test may be opened, for example, by removing fuses.

The measured value of the fault loop impedance shall be in accordance with A.1.2.

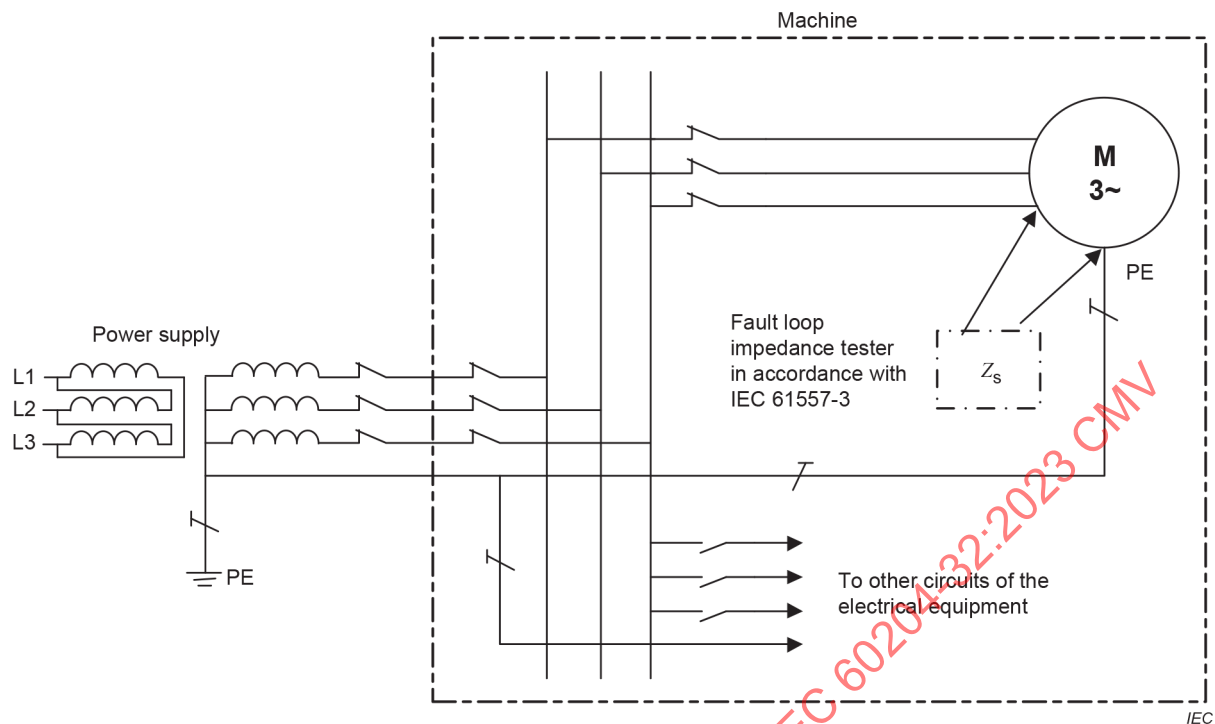


Figure A.1 – Typical arrangement for fault loop impedance (Z_s) measurement in TN systems

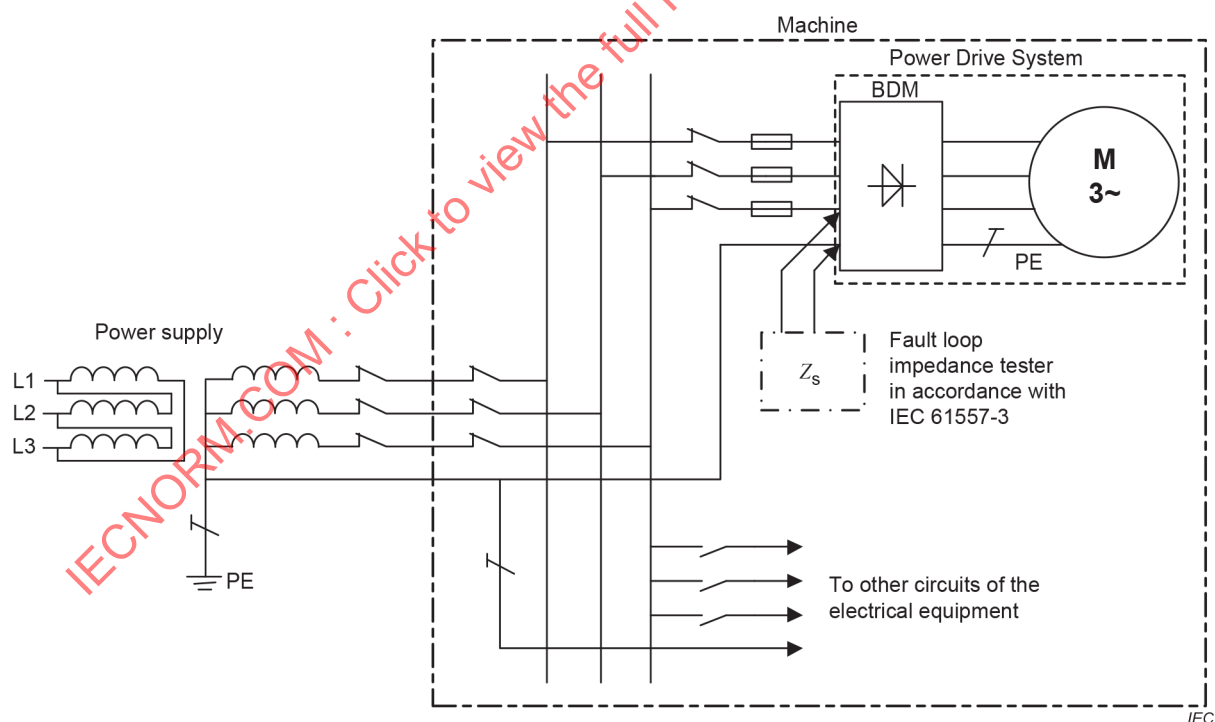


Figure A.2 – Typical arrangement for fault loop impedance (Z_s) measurement for power drive system circuits in TN systems

A.2 Fault protection for machines supplied from TT-systems

A.2.1 Connection to earth

All exposed-conductive-parts and all extraneous conductive parts shall be bonded to the protective bonding circuit.

Exception: see 8.2.5.

In addition to the requirements of 5.2, provision for additional earthing of machine elements and/or the PE conductor of the electrical equipment may be provided.

NOTE In a TT system, the neutral point or the mid-point of the power supply system is earthed, or where a neutral point or mid-point is not available or not accessible, a line conductor is earthed (derived from IEC 60364-4-41:2005, 411.5.1).

A.2.2 Fault protection for TT systems

A.2.2.1 General

Generally in TT systems, RCDs shall be used for fault protection. Alternatively, overcurrent protective devices may be used for fault protection provided a suitably low value of Z_s is permanently and reliably assured. Z_s is the impedance of the fault loop.

NOTE In some countries, the use of overcurrent protective devices is not permitted as the means of fault protection in TT systems.

Where automatic disconnection of supply is used as a measure for fault protection, the electrical equipment designer may either:

- a) use in the design calculations a value of earth electrode resistance or earth fault loop impedance measured in accordance with IEC 60364-6:2016 or declared by the intended user of the equipment (see Annex B); or
- b) for series-manufactured machines, specify a value of the earth electrode resistance or earth fault loop impedance suitable for the intended installations.

The electrical equipment designer shall state in the installation instructions the value of earth electrode resistance or earth fault loop impedance used for the design of the electrical equipment, specifying that this is the maximum value to which the machine can be connected.

Where a power drive system (PDS) is used, the disconnection time for fault protection shall meet the relevant requirements of this Annex A at the incoming supply terminals of the basic drive module (BDM) of the PDS. See Figure A.4.

A.2.2.2 Protection by residual current protective device (RCD)

Where a residual current protective device (RCD) is used for fault protection, the following conditions shall be fulfilled:

- a) disconnection time as required by Table A.2, and
- b) $R_A \times I_{\Delta n} \leq 50 \text{ V}$

where

R_A is the sum of the resistances of the earth electrode and the protective conductor for each exposed conductive-part;

$I_{\Delta n}$ is the rated residual operating current of the RCD.

Exception: a disconnection time not exceeding 1 s is permitted for distribution circuits and for circuits not covered by Table A.2.

NOTE 1 Fault protection is provided in this case also if the fault impedance is not negligible.

NOTE 2 Where discrimination between RCDs is necessary, information is given in 535.3 of IEC 60364-5-53:2019.

NOTE 3 The disconnection times in accordance with Table A.2 relate to prospective residual fault currents significantly higher than the rated residual operating current of the RCD (typically $5 I_{\Delta n}$).

NOTE 4 The definition of R_A is extracted from IEC 60364-4-41:2005. In this document, the term “earth electrode” in the definition of R_A is considered to mean the “earth-return path” as defined by IEC 60050-195:2021, 195-02-30.

A.2.2.3 Protection by overcurrent protective devices

Where an overcurrent protective device is used, the following condition shall be fulfilled:

$$Z_s \times I_a \leq U_0$$

where

Z_s is the impedance of the fault loop comprising:

- the source,
- the line conductor up to the point of the fault,
- the protective conductor of each exposed-conductive-part,
- the earthing conductor,
- the earth electrode of the installation and the earth electrode of the source;

I_a is the current causing the automatic operation of the disconnecting device within the time specified in Table A.2;

Exception: a disconnection time not exceeding 1 s is permitted for circuits not covered by Table A.2.

U_0 is the nominal AC or DC line-to-earth voltage.

The maximum disconnection times stated in Table A.2 shall be applied to circuits not exceeding 32 A. Maximum disconnection times shall not exceed 1 s for circuits 32 A or greater.

Table A.2 – Maximum disconnecting time for TT-systems

System	Maximum disconnecting time							
	s							
	$50 \text{ V} < U_0 \leq 120 \text{ V}$		$120 \text{ V} < U_0 \leq 230 \text{ V}$		$230 \text{ V} < U_0 \leq 400 \text{ V}$		$U_0 > 400 \text{ V}$	
	AC	DC	AC	DC	AC	DC	AC	DC
TT	0,3	NOTE	0,2	0,4	0,07	0,2	0,04	0,1
Where in TT systems the disconnection is achieved by an overcurrent protective device and all extraneous conductive parts will be connected to the protective bonding circuit, the maximum disconnection times specified in Table A.1 may be used. U_0 is the nominal AC or DC line-to-earth voltage. Disconnection can be required for reasons other than protection against electric shock.								

A.2.3 Verification of protection by automatic disconnection of supply using a residual current protective device (RCD)

Fault protection in a TT system by automatic disconnection of supply using an RCD shall be verified by the following:

- inspection of the rated residual current for tripping value, and the disconnecting time value of the RCD; and

- verification that the RCD has been tested in accordance with a relevant IEC standard; and
- inspection of the connections to the RCD and protective bonding circuit.

A.2.4 Measurement of the fault loop impedance (Z_s)

Where measurement of the fault loop impedance is performed, the measuring equipment should comply with IEC 61557-3. The information about the accuracy of the measuring results and the procedures to be followed given in the documentation of the measuring equipment shall be considered.

The measurement shall be performed with the electrical equipment connected to a supply of between 99 % and 101 % of the nominal frequency of the supply at the intended installation.

NOTE 1 Figure A.3 illustrates a typical arrangement for measuring the fault loop impedance on a machine.

If it is not practicable for the motor to be connected during the test, the two line conductors not used in the test may be opened, for example, by removing fuses.

NOTE 2 Figure A.4 illustrates a typical arrangement for measuring the fault loop impedance when a power drive system is used.

The measured value of the fault loop impedance shall be in accordance with A.2.2.3.

NOTE 3 Information on the verification of performance of an RCD and measurement of earth fault loop impedance can be found in IEC 60364-6:2016.

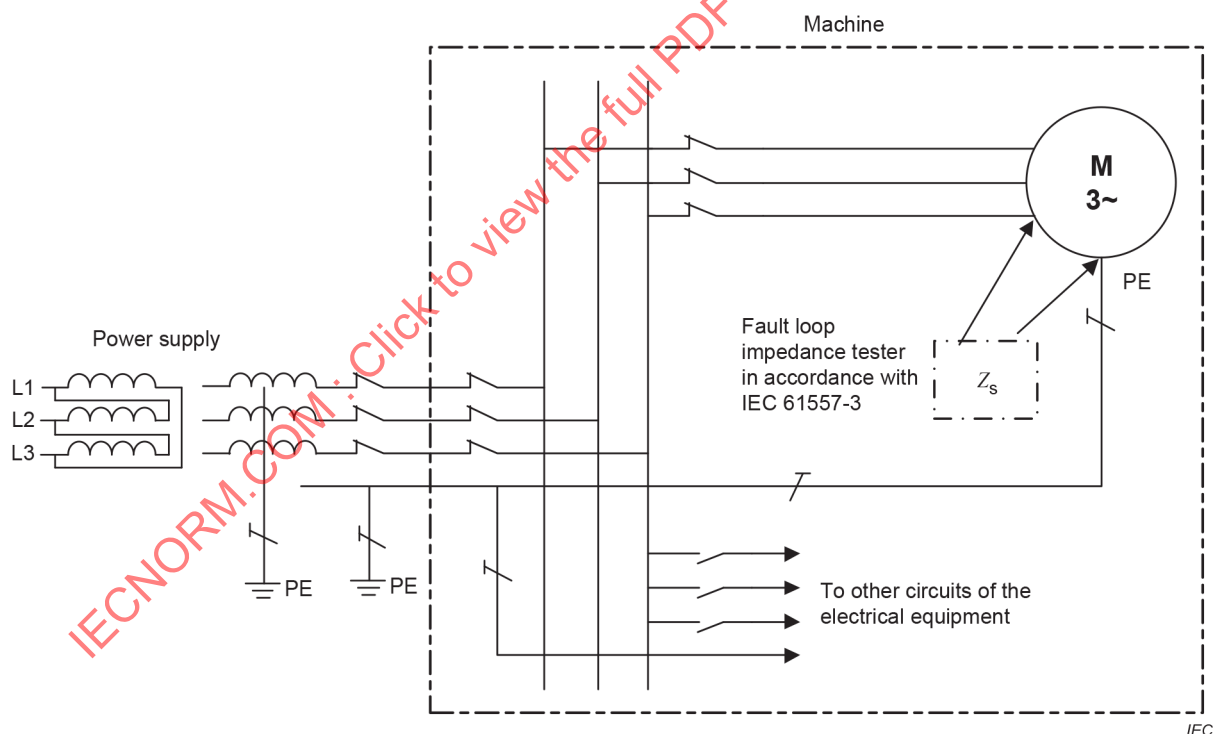


Figure A.3 – Typical arrangement for fault loop impedance (Z_s) measurement in TT systems

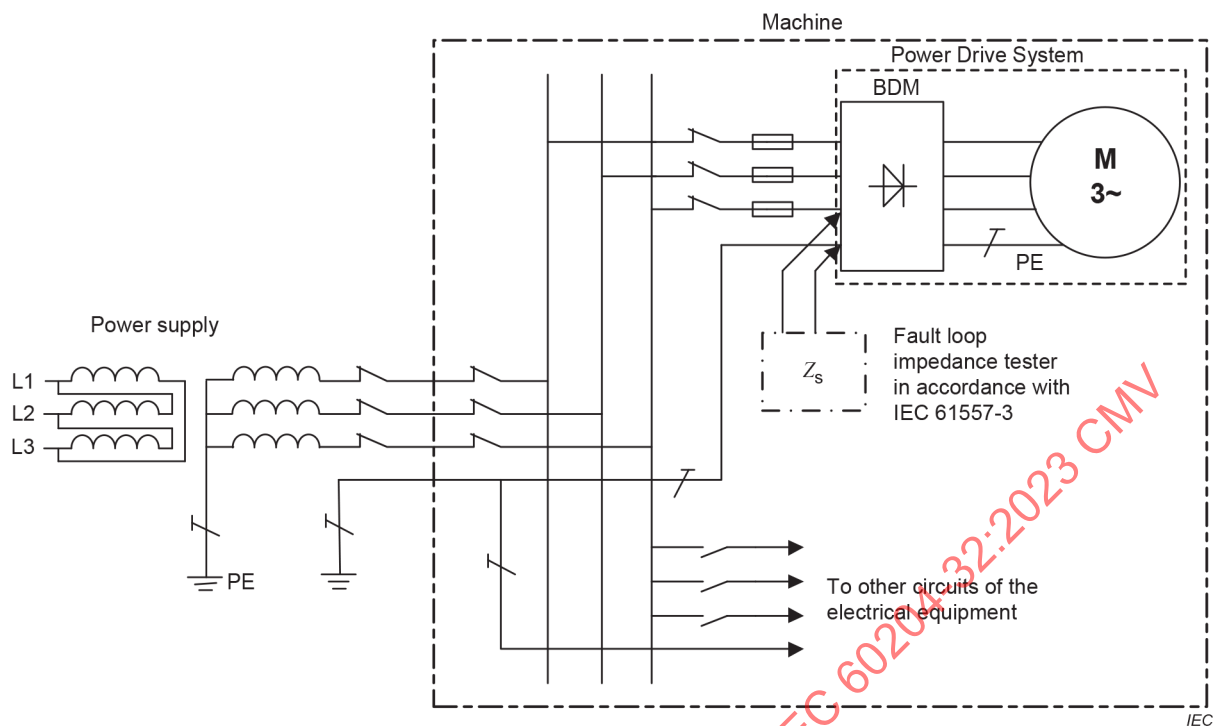


Figure A.4 – Typical arrangement for fault loop impedance (Z_s) measurement for Power Drive System circuits in TT systems

Annex B (informative)

Enquiry form for the electrical equipment of hoisting machines

The use of this enquiry form can facilitate an exchange of information between the user and supplier on basic conditions and additional user requirements to enable suitable design, application and utilization of the electrical equipment of the hoisting machine (see 4.1) particularly when the conditions on site can deviate from those generally expected.

Annex B can also serve as an internal checklist for serial manufactured hoisting machines.

Name of manufacturer/supplier			
Name of end user			
Tender/order number		Date	
Type of hoisting machine		Serial number	
1 Special conditions (see Clause 1)			
a) Is the hoisting machine to be used in the open air?	Yes	No	
b) Will the hoisting machine handle or transport explosive, flammable or otherwise hazardous material?	Yes/No	If yes, specification	
c) Is the hoisting machine for use in potentially explosive or flammable atmospheres?	Yes/No	If yes, specification	
d) Is the hoisting machine for use in mines?	Yes	No	
2 Electrical supplies and related conditions (see 4.3)			
a) Anticipated voltage fluctuations (if more than $\pm 10\%$)			
b) Anticipated frequency fluctuations (if more than $\pm 2\%$)	Continuous	Short time	
c) Indicate possible future changes in electrical equipment that will require an increase in the electrical supply requirements			
d) Specify voltage interruptions in supply if longer than specified in Clause 4 where electrical equipment has to maintain operation under such conditions			
3 Physical environment and operating conditions (see 4.4)			
a) Electromagnetic environment (see 4.4.2)	Residential, commercial or light industrial environment	Industrial environment	
Special EMC conditions or requirements			
b) Ambient temperature range			
c) Humidity range			
d) Altitude			
e) Special environmental conditions (e.g. corrosive atmospheres, dust, wet environments)			
f) Radiation			
g) Vibration, shock			
h) Special installation and operation requirements (e.g. flame-retardant cables and conductors)			

i) Transportation and storage (e.g. temperatures outside the range specified in 4.5)				
j) restrictions related to size, weight or point load				
4 Incoming electrical supplies				
Specify for each source of supply:				
a) Nominal voltage (V)	AC		DC	
	If AC, number of phases		Frequency	
Value of the supply source impedance (Ω) at the point of connection to the electrical equipment				
Prospective short-circuit current at the point of supply to the hoisting machine (kA RMS) (see also item 2)				
b) Type of power supply earthing (see IEC 60364-1:2005)	TN (system with one point directly earthed, with a protective conductor (PE) directly connected to that point); specify if the earthed point is the neutral point (centre of the star) or another point		TT (system with one point directly earthed but the protective conductor (PE) of the hoisting machine not connected to that earth point of the system)	
	IT (system that is not directly earthed)			
In the case of IT systems, is insulation monitoring/fault location to be provided by the supplier of the electrical equipment?	Yes		No	
c) Is the electrical equipment to be connected to a neutral (N) supply conductor? (see 5.1)	Yes		No	
d) Crane-supply-switch				
Is disconnection of the neutral (N) conductor required?	Yes		No	
Is a removable link for disconnecting the neutral (N) required?	Yes		No	
Type of crane-supply-switch to be provided				
e) Cross sectional area and material of external protective (PE) conductor				
f) Is an RCD provided in the installation?	Yes/No		If yes, type and rated residual operating current	
5 Protection against electric shock (see Clause 6)				
a) For which of the following classes of persons is access to the interior of enclosures required during normal operation of the equipment?	Electrically skilled persons		Electrically instructed persons	
b) Are locks with removable keys to be provided for securing the doors or covers? (see 6.2.2)	Yes		No	
Type of locking device				
Basic lock unit (except key cylinder) to be supplied and installed by				
Key cylinder to be supplied and installed by				

6	Protection of equipment (see Clause 7)			
	a) Will the user or the supplier provide the overcurrent protection of the supply conductors? (see 7.2.2)			
	Type and rating of overcurrent protective devices			
	b) Largest (kW) three-phase AC motor that may be started direct-on-line			
	c) May the number of motor overload detection devices be reduced? (see 7.3)	Yes		No
	d) Is overvoltage protection to be provided?	Yes		If yes, specification
7	Operation			
	For cableless control systems, specify the time delay before automatic hoisting machine shutdown is initiated in the absence of a valid signal. (see 9.2.7.3)			
8	Operator interface and machine-mounted control devices (see Clause 10)			
	Special colour preferences (e.g. to align with existing machinery)	Start		Stop
		Other		
9	Controlgear			
	Degree of protection of enclosures (see 11.3) or special conditions:			
10	Wiring practices (see Clause 13)			
	Is there a specific method of identification to be used for the conductors? (see 13.2.1)	Yes		No
	Type			
11	Accessories and lighting (see Clause 15)			
	a) Is a particular type of socket-outlet required?	Yes		No
	If yes, which type?			
	b) Are the socket-outlets for maintenance to be provided with additional protection by the use of residual current protective devices (RCDs)?	Yes		No
	c) Where the hoisting machine is equipped with local lighting	Highest permissible voltage (V)		If lighting circuit voltage is not obtained directly from the power supply, state preferred voltage
12	Marking, warnings and reference designations (see Clause 16)			
	a) Functional identification (see 16.3)			
	Specifications:			
	b) Inscriptions/special markings	On electrical equipment?		In which language?
	c) Mark of certification	Yes		No
	If yes, which one?			

13 Technical documentation (see Clause 17)				
a) Technical documentation (see 17.1)	On what media?		In which language?	
b) Size, location and purpose of ducts, open cable trays or cable supports to be provided by the user (see 13.5)				
c) Indicate if special limitations on the size or weight affect the transport of a particular hoisting machine or controlgear assemblies to the installation site	Maximum dimensions		Maximum weight	
14 Intended use of the hoisting machine (see 12.4 and Annex D)				
What is the mean number of operating cycles per hour? (An operating cycle comprises all operations in all axes, beginning with the hoisting of a load and ending when the hoisting machine is ready for hoisting the next load.)				
For what length of time is it expected that the hoisting machine will be operated at this rate without subsequent pause?				
Length of subsequent pause?				

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Annex C (informative)

Current-carrying capacity and overcurrent protection of conductors and cables in the electrical equipment of machines

C.1 General

The purpose of this Annex C is to provide additional information on the selection of conductor sizes where the conditions given for Table 7 (see Clause 12) have to be modified (see notes to Table 7).

C.2 General operating conditions

C.2.1 Ambient air temperature

The current-carrying capacity for PVC-insulated conductors given in Table 7 is related to an ambient air temperature of +40 °C. For other ambient air temperatures, the correction factors are given in Table C.1.

The correction factors for rubber insulated cables are given by the manufacturer.

Table C.1 – Correction factors

Ambient air temperature °C	Correction factor
30	1,15
35	1,08
40	1,00
45	0,91
50	0,82
55	0,71
60	0,58
NOTE The correction factors are derived from IEC 60364-5-52. The maximum conductor temperature under normal conditions for PVC is 70 °C	

C.2.2 Methods of installation

In machines, the methods of conductor and cable installation between enclosures and individual items of the equipment shown in Figure C.1 are assumed to be typical (the letters used are in accordance with IEC 60364-5-52).

- Method B1: using conduits (see 3.1.12) and cable trunking systems (see 3.1.9) for holding and protecting conductors or single core cables
- Method B2: same as B1 but used for multi-core cables
- Method C: multi-core cables installed in free air, horizontal or vertical without gap between cables on walls
- Method E: multi-core cables in free air, horizontal or vertical laid on open cable trays (see 3.1.8)

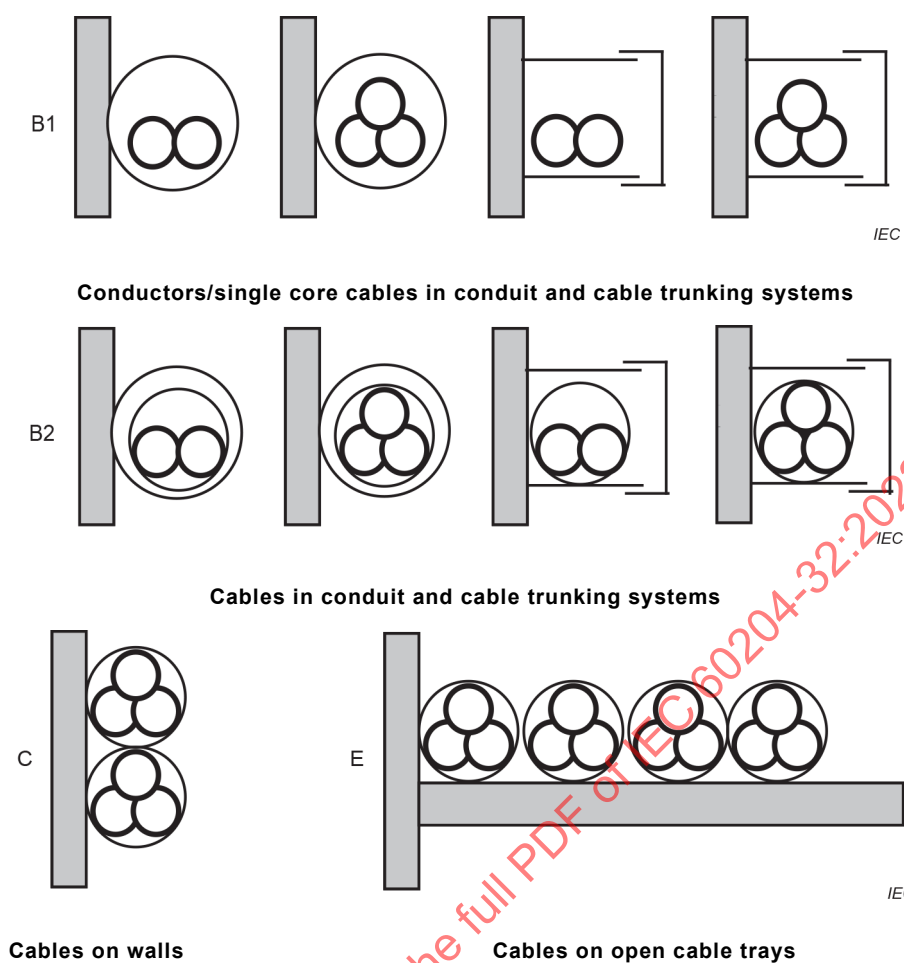


Figure C.1 – Methods of conductor and cable installation independent of number of conductors/cables

C.2.3 Grouping

Where more loaded conductors in cables or conductor pairs are installed, the values of I_z , given in Table 7 or by the manufacturer in accordance with Table C.2 or Table C.3, should be derated.

NOTE Circuits with $I_b < 30\%$ of I_z need not be derated.

Table C.2 – Derating factors for I_z for grouping

Method of installation (see Figure C.1)	Derating factor			
	Number of loaded circuits/cables			
	2	4	6	9
B1 (conductors or single core cables) and B2 (multicore cables)	0,80	0,65	0,57	0,50
C single layer with no gap between cables	0,85	0,75	0,72	0,70
E single layer on one perforated tray without gap between	0,88	0,77	0,73	0,72
E as before but with 2 to 3 trays, with a vertical spacing between each tray of 300 mm (see Note 4)	0,86	0,76	0,71	0,66
Control circuit pairs $\leq 0,5 \text{ mm}^2$ independent of methods of installation	0,76	0,57	0,48	0,40
NOTE 1 These factors are applicable to – cables, all equally loaded, the circuit itself symmetrically loaded; – groups of circuits of insulated conductors or cables having the same allowable maximum operating temperature. NOTE 2 The same factors are applied to – groups of two or three single-core cables; – multi-core cables. NOTE 3 Factors derived from IEC 60364-5-52. NOTE 4 A perforated cable tray is a tray where the holes occupy more than 30 % of the area of the base (derived from IEC 60364-5-52).				

Table C.3 – Derating factors for I_z for multi-core cables up to 10 mm^2

Number of loaded conductors or pairs	Derating factor	
	Conductors $\geq 1 \text{ mm}^2$ (see Note 3)	Pairs ($0,25 \text{ mm}^2$ to $0,75 \text{ mm}^2$)
1	-	1,0
3	1,0	0,5
5	0,75	0,39
7	0,65	0,34
10	0,55	0,29
24	0,40	0,21
NOTE 1 Applicable to multi-core cables with equally loaded conductors/pairs. NOTE 2 For grouping of multi-core cables, see derating factors of Table C.2. NOTE 3 Factors derived from IEC 60364-5-52.		

C.2.4 Classification of conductors

Classification of conductors is given in Table C.4.

Table C.4 – Classification of conductors

Class	Description	Use/application
1	Solid copper or aluminium conductors	Fixed installations
2	Stranded copper or aluminium conductors	
5	Flexible stranded copper conductors	Machine installations with presence of vibration; connection to moving parts For frequent movements
6	Flexible stranded copper conductors that are more flexible than class 5	
NOTE Derived from IEC 60228.		

C.3 Co-ordination between conductors and protective devices providing overload protection

Figure C.2 illustrates the relationship between the parameters of conductors and the parameters of protective devices providing overload protection.

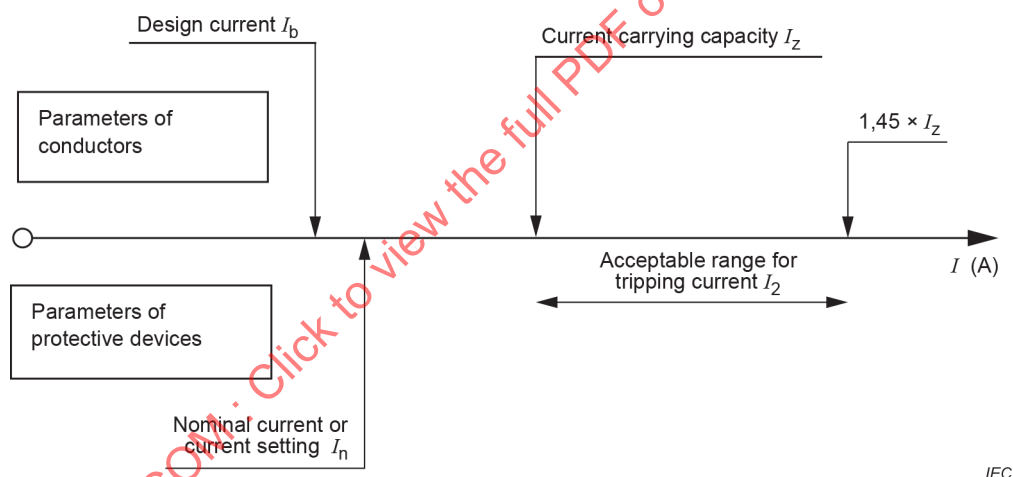


Figure C.2 – Parameters of conductors and protective devices

Correct protection of a cable requires that the operating characteristics of a protective device (e.g. overcurrent protective device, motor overload protective device) protecting the cable against overload satisfy the two following conditions:

$$I_b \leq I_n \leq I_z \quad (\text{C.1})$$

$$I_2 \leq 1,45 \times I_z \quad (\text{C.2})$$

where

I_b is the current for which the circuit is designed;

I_z is the effective current-carrying capacity, in amperes, of the cable for continuous service in accordance with Table 7 for the particular installation conditions:

- temperature, for derating of I_z see Table C.1;
- grouping, for derating of I_z see Table C.2;
- multi-core cables, for derating of I_z see Table C.3.

I_n is the nominal current of the protective device;

NOTE 1 For adjustable protective devices, the nominal current I_n is the current setting selected.

I_2 is the minimum current ensuring effective operation of the protective device within a specified time (e.g. 1 h for protective devices up to 63 A).

The current I_2 ensuring effective operation of the protective device is given in the product standard or may be provided by the manufacturer.

NOTE 2 For motor circuit conductors, overload protection for conductor(s) can be provided by the overload protection for the motor(s) whereas the short-circuit protection is provided by short-circuit protective devices.

Where a device that provides both overload and short-circuit protection is used in accordance with Clause C.3 for conductor overload protection, it does not ensure complete protection in all cases (e.g. overload with currents less than I_2) nor will it necessarily result in an economical solution. Therefore, such a device can be unsuitable where overloads with currents less than I_2 are likely to occur.

C.4 Overcurrent protection of conductors

All conductors are required to be protected against overcurrent (see 7.2) by protective devices inserted in all live conductors so that any short-circuit current flowing in the cable is interrupted before the conductor has reached the maximum allowable temperature. Maximum allowable conductor temperatures under normal and short-circuit conditions are given in Table C.5.

NOTE For neutral conductors, see 7.2.3, second paragraph.

Table C.5 – Maximum allowable conductor temperatures under normal and short-circuit conditions

Type of insulation	Maximum temperature under normal conditions °C	Ultimate short-time conductor temperature under short circuit conditions ^a °C
Polyvinyl chloride (PVC)	70	160
Rubber	60	200
Cross-linked polyethylene (XLPE)	90	250
Ethylene propylene compound (EPR)	90	250
Silicone rubber (SiR)	180	350
NOTE For ultimate short-time conductor temperatures greater than 200 °C, neither tinned nor bare copper conductors are suitable. Silver-plated or nickel-plated copper conductors are suitable for use above 200 °C.		
^a These values are based on the assumption of adiabatic behaviour for a period of not more than 5 s.		

In practice, the requirements of 7.2 are fulfilled when the protective device at a current I causes the interruption of the circuit within a time that in no case exceeds the time t where $t < 5$ s.

The value of the time t in seconds can be calculated using the following formula:

$$t = (k \times S/I)^2$$

where

S is the cross-sectional area in square millimetres;

I is the effective short-circuit current in amperes expressed for AC as the RMS value;

k is the factor shown for copper conductors when insulated with the following material:

PVC	115
Rubber	141
SiR	132
XLPE	143
EPR	143

The use of fuses with characteristics gG or gM (see IEC 60269-1:2009) and circuit-breakers with characteristics B and C in accordance with the IEC 60898 series, ensures that the temperature limits in Table C.5 will not be exceeded, provided that the nominal current I_n is chosen in accordance with Table 7 where $I_n \leq I_z$.

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Annex D (informative)

Conductor selection for intermittent duty

D.1 General

For specific applications where the correct conductor dimensioning can depend on the relationship between the period of the duty cycle and the thermal time constant of the conductor, the conductor manufacturer should be consulted. Conductors for intermittent duty should be selected in accordance with the conductor manufacturer's instructions. If such information is not available, the criteria presented in this Annex D can be used.

The method presented in Clause D.2 assumes that the cycle consists of an on-time and off-time. During on-time the current is at a constant level and during off-time there is no current. The cycle time (on-time plus off-time) is assumed to be 10 min.

If the cycle time is other than 10 min, it can be calculated in accordance with Clause D.3.

In some applications, the current during the on-time varies and also the cycle time can vary. The thermal equivalent current representing these variations can be calculated by applying Clause D.4.

D.2 Intermittent duty with 10-min cycle

Conductor selection for intermittent use should be made according to the conductor manufacturer's instructions. If such information is not available, the criteria presented in Clause D.2 can be used.

Table D.1 defines the correction factor f_{ED} for conductor current-carrying capacity in intermittent duty when the duration of the operating cycle is 10 min.

The correction factor depends on the duration of the load cycle compared to the thermal time constant of the conductor. Intermittent use consists of

- on-time (T_a), and
- off-time (T_i).

Table D.1 – Correction factor for 10 min cycle

Cross-section mm ²	Correction factor, f_{ED} , for a 10-min cycle $Ta/(Ta + Ti)$			
	0,6	0,4	0,25	0,15
1,5	1,044	1,120	1,265	1,505
2,5	1,058	1,150	1,315	1,580
4	1,075	1,183	1,369	1,660
6	1,092	1,215	1,421	1,737
10	1,116	1,260	1,493	1,842
16	1,139	1,303	1,561	1,942
25	1,161	1,344	1,626	2,037
35	1,177	1,373	1,673	2,105
50	1,193	1,403	1,719	2,173
70	1,207	1,429	1,760	2,231
95	1,219	1,450	1,793	2,280
120	1,227	1,464	1,816	2,314
150	1,234	1,477	1,836	2,343
185	1,240	1,488	1,854	2,369
240	1,247	1,501	1,874	2,397
300	1,252	1,510	1,888	2,419

D.3 Intermittent duty with any cycle time

If the duration of the operating cycle is shorter than 10 min, higher correction factors than in Table D.1 can be used, and if the duration of the operating cycle is longer, then lower correction factors should be applied. Correction factors to any particular operating cycle can be calculated using the following formula:

$$f_{ED} = \sqrt{\frac{1 - e^{-\left(\frac{Ta + Ti}{T}\right)}}{1 - e^{-\left(\frac{Ta}{T}\right)}}$$

Where T is the thermal time constant of the conductor, which can be taken from Table D.2.

Table D.2 – Thermal time constant of conductors

Cross-sectional area (mm ²)	1,5	2,5	4	6	10	16	25	35	50	70	95	120	150	185	240	300
T (min)	2,7	3,1	3,6	4,2	5,2	6,4	7,9	9,4	11,3	13,6	16,1	18,4	21,0	23,7	27,7	31,8

D.4 Calculation of thermal equivalent current

For intermittent periodic duty applications (e.g. where frequent motor starting occurs), it is recommended that conductors suitable for the thermal equivalent current, I_q , be selected. I_q is also used for coordination with overcurrent protection. I_q may be calculated as follows:

$$I_q = \sqrt{\frac{\sum_{k=1}^N I_k^2 \times t_k}{t_s}}$$

where

I_q is the thermal equivalent current in amperes;

t_s is the duty cycle time in seconds;

I_k, t_k are the current and time of the segments of the operating cycle.

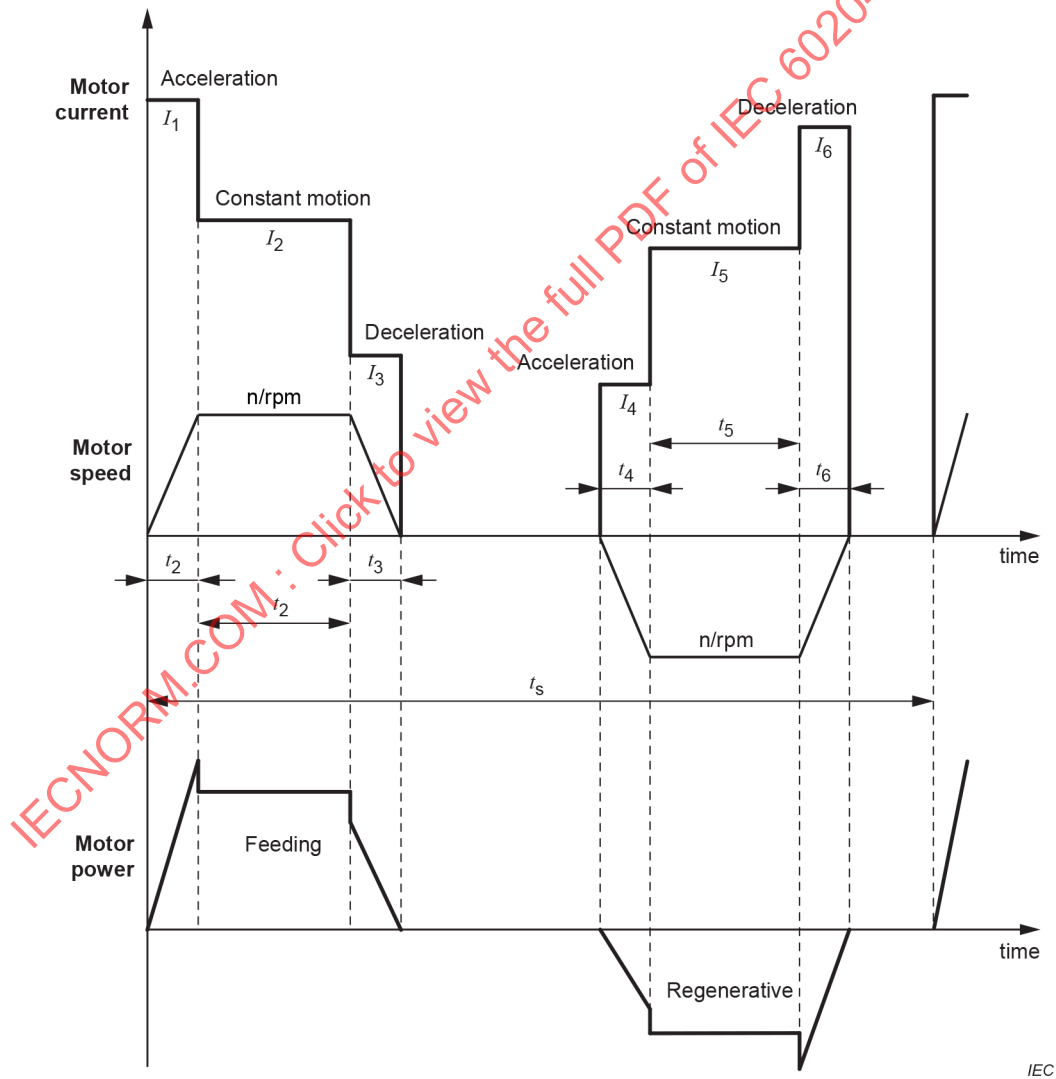


Figure D.1 – An example of current and time of the segments of the operating cycle of a variable speed AC hoist drive

For example, the thermal equivalent current for the operating cycle illustrated in Figure D.1 can be calculated using the following formula:

$$I_q = \sqrt{\frac{I_1^2 \times t_1 + I_2^2 \times t_2 + I_3^2 \times t_3 + I_4^2 \times t_4 + I_5^2 \times t_5 + I_6^2 \times t_6}{t_s}}$$

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Annex E (informative)

Explanation of emergency operation functions

E.1 Emergency operations

Emergency operation includes separately or in combination:

- emergency stop (E.2);
- emergency start (E.3);
- emergency switching-off (E.4);
- emergency switching-on (E.5).

NOTE These concepts are included here to give the reader an understanding of these terms, even though in this document only two of them are used.

E.2 Emergency stop

This is an emergency operation intended to stop a process or a movement that has become hazardous.

E.3 Emergency start

This is an emergency operation intended to start a process or a movement to remove or to avoid a hazardous situation.

E.4 Emergency switching-off

This is an emergency operation intended 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.

E.5 Emergency switching-on

This is an emergency operation intended to switch on the supply of electrical energy to a part of an installation that is intended to be used for emergency situations.

Annex F (informative)

Comparison of typical conductor cross-sectional areas

Table F.1 provides a comparison of the conductor cross-sectional areas of the American Wire Gauge (AWG) with square millimetres, square inches, and circular mils.

Table F.1 – Comparison of conductor sizes

Wire size mm ²	Gauge No. (AWG)	Cross-sectional area		DC resistance of copper at 20 °C Ω/km	Circular mils
		mm ²	in ²		
0,2		0,196	0,000 304	91,62	387
	24	0,205	0,000 317	87,60	404
0,3		0,283	0,000 438	63,46	558
	22	0,324	0,000 504	55,44	640
0,5		0,500	0,000 775	36,70	987
	20	0,519	0,000 802	34,45	1 020
0,75		0,750	0,001 162	24,80	1 480
	18	0,823	0,001 272	20,95	1 620
1,0		1,000	0,001 550	18,20	1 973
	16	1,31	0,002 026	13,19	2 580
1,5		1,500	0,002 325	12,20	2 960
	14	2,08	0,003 228	8,442	4 110
2,5		2,500	0,003 875	7,56	4 934
	12	3,31	0,005 129	5,315	6 530
4		4,000	0,006 200	4,700	7 894
	10	5,26	0,008 152	3,335	10 380
6		6,000	0,009 300	3,110	11 841
	8	8,37	0,012 967	2,093	16 510
10		10,000	0,015 50	1,840	19 735
	6	13,3	0,020 610	1,320	26 240
16		16,000	0,024 800	1,160	31 576
	4	21,1	0,032 780	0,829 5	41 740
25		25,000	0,038 800	0,734 0	49 338
	2	33,6	0,052 100	0,521 1	66 360
35		35,000	0,054 200	0,525 7	69 073
	1	42,4	0,065 700	0,413 9	83 690
50		50,000	0,077 5	0,368 0	99 072
	0	47	0,072 87	0,391 5	93 128

The resistance for temperatures other than 20 °C can be found using the formula:

$$R = R_1 [1 + 0,003\,93 (t - 20)]$$

where

R_1 is the resistance at 20 °C;

R is the resistance at a temperature t °C

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Annex G (informative)

Measures to reduce the effects of electromagnetic influences

G.1 General

This Annex G provides recommendations to improve electromagnetic immunity and reduce emission of electromagnetic disturbances.

For EMC purposes, electrical equipment for machinery is deemed to be either apparatus or fixed installations. Where electrical safety and electromagnetic compatibility result in different requirements, electrical safety always has the higher priority.

Electromagnetic interference (EMI) can disturb or damage process monitoring, control and automation systems. Currents due to lightning, switching operations, short-circuits and other electromagnetic phenomena can cause overvoltages and electromagnetic interference.

These effects can occur for example:

- where large conductive loops exist,
- where different electrical wiring systems are installed in common routes, e.g. power supply, communication, control or signal cables.

Cables carrying large currents with a high rate of change of current (di/dt) can induce overvoltages in other cables, which can influence or damage the connected electrical equipment.

In some applications, immunity and/or emission requirements of the electrical equipment can be met when the following conditions are fulfilled:

- the incorporated devices and components comply with the EMC requirements for the intended EMC environment specified in the relevant product standard (or generic standard where no product standard exists); and
- the electrical installation and wiring are consistent with the instructions provided by the supplier of the devices and components with regard to mutual influences (cabling, screening, earthing etc.) or with informative Annex G if such instructions are not available from the supplier.

G.2 Mitigation of electromagnetic interference (EMI)

G.2.1 General

Consideration should be given, in the design of the electrical equipment to the measures described in G.2.2 for reducing the electromagnetic influences on electrical equipment.

Only electrical equipment which meets the requirements of the appropriate EMC standards, or the EMC requirements of the relevant product standard, should be used.

G.2.2 Measures to reduce EMI

The following measures reduce electromagnetic interference.

- a) The installation of surge protection devices and/or filters for equipment sensitive to electromagnetic influences is recommended to improve electromagnetic compatibility with regard to conducted electromagnetic phenomena.
- b) Conductive sheaths (e.g. armouring, screens) of cables should be bonded to the protective bonding circuit.
- c) Inductive loops should be avoided by selection of common routes for power, signal and data circuits wiring while maintaining circuit separation in accordance with Clause G.3.
- d) Power cables should be kept separate from signal or data cables.
- e) Where it is necessary for power and signal or data cables to cross each other, they should be crossed at right-angles.
- f) Cables with concentric conductors are used to reduce currents induced into the protective conductor.
- g) Symmetrical multicore cables (e.g. screened cables containing separate protective conductors) are used for the electrical connections between motors and converters.
- h) Signal and data cables are used according to the EMC requirements of the manufacturer's instructions.
- i) Where screened signal or data cables are used, care should be taken to reduce current flowing through the screens of signal cables, or data cables, which are earthed. It can be necessary to install a by-pass conductor; see Figure G.1.

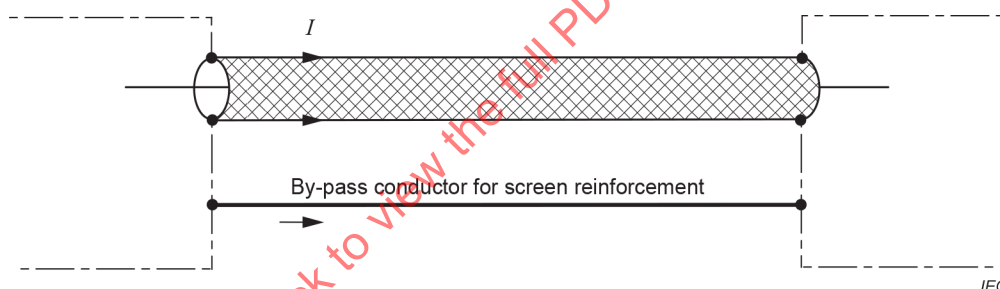


Figure G.1 – By-pass conductor for screen reinforcement

NOTE A good equipotential bonding of the components of the machine reduces the need for by-pass conductors.

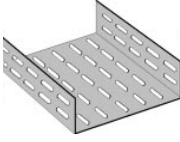
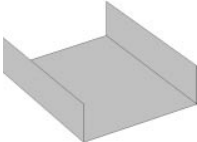
- j) Equipotential bonding connections should have an impedance as low as practicable by being as short as practicable and where applicable braided to conduct higher frequencies.
- k) If electronic equipment requires a reference voltage at about earth potential in order to function correctly, this reference voltage is provided by the functional earthing conductor. For equipment operating at high frequencies, the connections shall be kept as short as practicable.

G.3 Separation and segregation of cables

Power cables and data cables which share the same route should be installed according to the requirements of this Annex G.

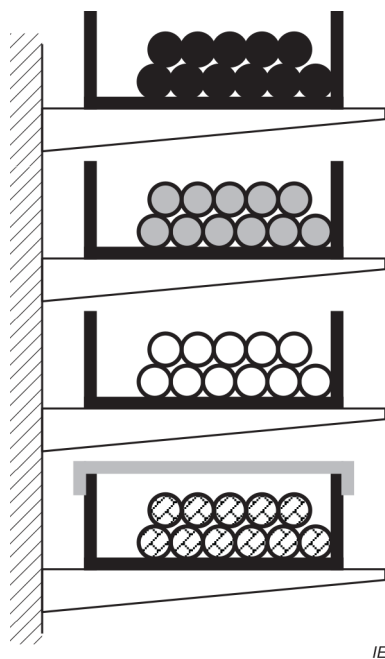
Where no other information is available, then the cable separation distance between the power and data cables should be in accordance with Table G.1 and Figure G.2.

Table G.1 – Minimum separation distances using metallic containment as illustrated in Figure G.2

Separation without metallic containment	A Mesh metallic containment 	B Perforated metallic containment 	C Solid metallic containment 
≥ 200 mm	≥ 150 mm	≥ 100 mm	0 mm
A Screening performance (DC-100 MHz) equivalent to welded mesh steel basket of mesh size 50 mm × 100 mm (excluding ladders). This screening performance is also achieved with steel tray even if the wall thickness is less than 1 mm and/or the evenly distributed perforated area is greater than 20 %. B Screening performance (DC-100 MHz) equivalent to steel tray of at least 1 mm wall thickness and no more than 20 % evenly distributed perforated area. This screening performance is also achieved with screened power cables. No part of the cable within the metallic containment should be less than 10 mm below the top of the metallic containment. C Screening performance (DC-100 MHz) equivalent to a steel conduit of at least 1 mm wall thickness. Separation specified is in addition to that provided by any divider/screen.			

The minimum separation requirement specified in Table G.1 applies to the horizontal or vertical separation between adjacent cable trays or cable trunking systems. Where data cables and power supply cables are required to cross and required minimum separation cannot be maintained then the angle of their crossing should be maintained at 90 degrees on either side of the crossing for a distance no less than the applicable minimum separation requirement.

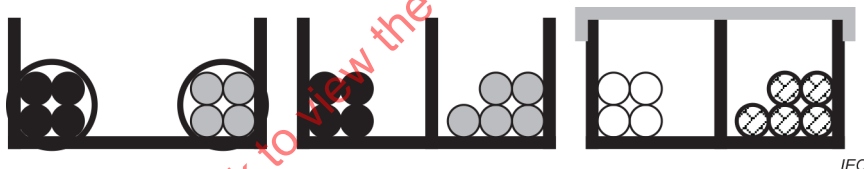
Figure G.2 and Figure G.3 show examples of separation and segregation.



For distances see Table G.1

 power supply cabling	 auxiliary circuits
 data cabling	 sensitive circuits (e.g. measurement)

Figure G.2 – Examples of vertical separation and segregation



For distances see Table G.1

Figure G.3 – Examples of horizontal separation and segregation

Usable space within the cable tray or cable trunking system should allow for an agreed quantity of additional cables to be installed (see Annex B). The cable bundle height should be lower than the side-walls of the cable tray or cable trunking system, as shown in Figure G.4. The overlapping lid of cable trunking systems improves the electromagnetic compatibility performance.

For a U-shape cable tray, the magnetic field decreases near the two corners. For this reason, deep side-walls are preferred.

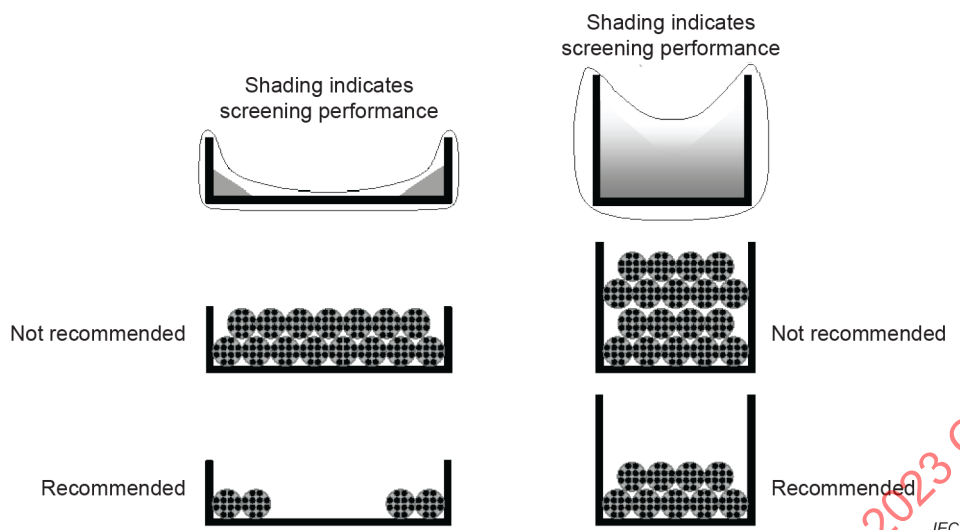


Figure G.4 – Cable arrangements in metal cable trays

Metal cable trays or cable trunking systems which are intended to provide electromagnetic compatibility shall always be connected to the local equipotential bonding system at both ends. For long distances, for example greater than 50 m, additional connections to the equipotential bonding system are recommended. All connections to the equipotential bonding system should have low impedance.

Where metal cable trays or cable trunking systems are constructed from several elements, care should be taken to ensure continuity by effective bonding between adjacent elements.

The shape of the metallic section should achieve continuity of shielding throughout its length. All interconnections should have low impedance; see Figure G.5.

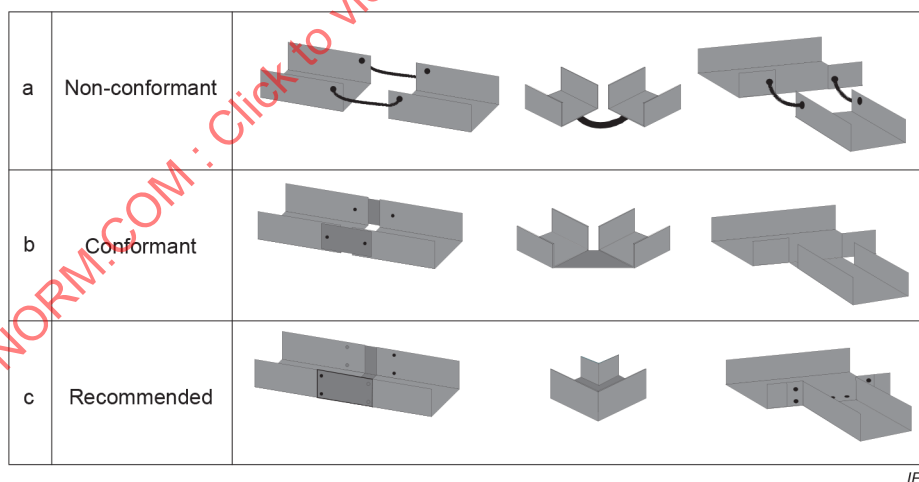


Figure G.5 – Connections between metal cable trays or cable trunking systems

Where metallic covers for metallic cable trunking systems are used, a cover over the full length is preferred. If that is not possible, the covers should be connected to the cable tray at least at both ends by short connections less than 10 cm, e.g. braided or mesh straps.

Figure G.6 shows a metal cable tray crossing a wall at which a fire barrier is to be installed. Where metal cable trays are required to be interrupted to pass through building structures, a low impedance interconnection should be provided between the two metallic sections. Regulations with respect to fire barriers take precedence over EMC considerations.

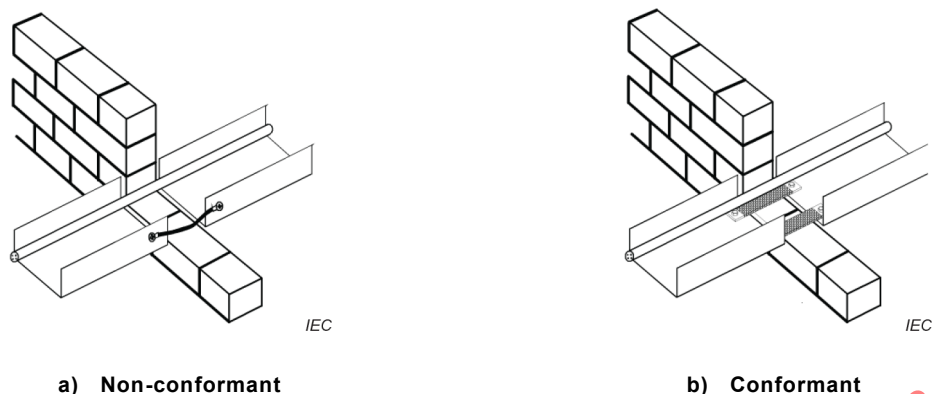


Figure G.6 – Interruption of metal cable trays at fire barriers

G.4 Power supply of a machine by parallel sources

Where a machine is supplied with power by parallel sources, see IEC 60364-1:2005.

G.5 Supply impedance where a Power Drive System (PDS) is used

Connection of a PDS to too high a supply source impedance can lead to conducted emission problems.

G.6 Emission levels for electrical equipment for PDS

Limits for the interference voltage for the environments and categories are listed in Table G.2.

Table G.2 – Limits for the interference voltage for the environments / categories

Location	Frequency range MHz	Residential environment		Residential or Industrial environments (Residential when fixed installation by expert staff and warning notice)		Industrial environment with warning notice			
		PDS of category C1		PDS of category C2		PDS of category C3			
						PDS $I \leq 100$ A		PDS $I > 100$ A	
		Quasi peak dB μ V/m	Average dB μ V/m	Quasi peak dB μ V/m	Average dB μ V/m	Quasi peak dB μ V/m	Average dB μ V/m	Quasi peak dB μ V/m	Average dB μ V/m
AC power port	0,15	66	56	79	66	100	90	130	120
	0,50	56	46	79	66	100	90	130	120
	0,50	56	46	73	60	86	76	125	115
	5,00	56	46	73	60	86	76	125	115
	5,00	60	50	73	60	90	80	115	105
	30,00	60	50	73	60	70	60	115	105
Enclosure	30,00	30		40		50		50	
	230,00	30		40		50		50	
	230,00	37		47		60		60	
	1 000,00	37		47		60		60	

Table G.3 – Limits for propagated electromagnetic disturbance

	Frequency range	Magnetic field strength component expressed in electric field units – quasi peak
	MHz	Quasi peak dB $\mu\text{V}/\text{m}$
Radiation	$0,15 \leq f \leq 0,49$	75
	$0,49 < f \leq 3,95$	65
	$3,95 < f \leq 20$	50
	$20 < f \leq 30$	40
	$30 \leq f \leq 230$	30
	$230 < f \leq 1\,000$	37

In case of interference, the radiation shall be measured at a distance of 10 m from the boundary of the installation if interference occurs outside in the first environment, or at a distance of 30 m from the boundary of the installation if interference occurs outside in the second environment.

For PDSs of category C4, the following procedure shall be used.

Due to technical reasons, there are some applications where it is not possible for the PDS to comply with the limits of Table G.3. These applications are for large ratings or to meet specific technical requirements:

- voltage above 1 000 V;
- current above 400 A;
- networks isolated from earth, or connected to earth through a high impedance (IT system according to 312.2.3 of IEC 60364-1:2005);
- where required dynamic performances will be limited as a result of filtering.

In these applications of category C4 equipment, the user and the manufacturer shall agree on an EMC plan to meet the EMC requirements of the intended application.

G.7 Conducted disturbances

Limits for conducted disturbances are given in Table G.4.

Table G.4 – Limits for conducted disturbances

	Frequency range	Residential environment		Industrial environments (Residential when fixed installation by expert staff and warning notice)		Industrial environments (not allowed in Residential environment)	
		PDS of category C1		PDS of category C2		PDS of category C3	
	MHz	Quasi peak dB $\mu\text{V}/\text{m}$	Average dB $\mu\text{V}/\text{m}$	Quasi peak dB $\mu\text{V}/\text{m}$	Average dB $\mu\text{V}/\text{m}$	Quasi peak dB $\mu\text{V}/\text{m}$	Average dB $\mu\text{V}/\text{m}$
Conduction	0,15	66	56	79	66	100	90
	0,50	56	46	79	66	100	90
	0,50	56	46	73	60	86	76
	5,00	56	46	73	60	86	76
	5,00	60	50	73	60	90	80
	30,00	60	50	73	60	70	60

G.8 Immunity requirements – Performance criteria

A functional description and a definition of equipment under test (EUT) specific performance criteria, during or as a consequence of immunity testing, shall be provided by the manufacturer and noted in the test report. They shall be consistent with one of the following general criteria for each test as specified:

- a) Performance criterion A: The EUT shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the EUT is used as intended. If the performance level is not specified by the manufacturer, this may be derived from the product description and documentation and what the user may reasonably expect from the equipment if used as intended.
- b) Performance criterion B: The EUT shall continue to operate as intended after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the EUT is used as intended. The performance level may be replaced by a permissible loss of performance. However, during the test degradation of performance is allowed but no change of actual operating state or stored data is allowed. If the minimum performance level or the permissible performance loss is not specified by the manufacturer, either of these may be derived from the product description and documentation and what the user may reasonably expect from the equipment if used as intended.
- c) Performance criterion C: Temporary loss of function is allowed during the test, provided the function is self-recoverable or can be restored by the operation of the controls. If, as a result of the application of the tests defined in this document, the EUT becomes dangerous or unsafe, it shall be deemed to have failed the test.

NOTE For further information see IEC 61000-6-2.

For immunity requirements and performance criteria, see Table G.5.

Table G.5 – Immunity requirements – performance criteria

Environmental phenomena	Test specifications	Performance criterion	See basic standards
Radio frequency magnetic field. Amplitude modulated	80 MHz to 1 000 MHz 10 V/m 80 % AM (1 kHz)	A	IEC 61000-4-3
Electrostatic discharge. Contact discharge	±4 kV	B	IEC 61000-4-2
Electrostatic discharge. Air discharge	±8 kV	B	IEC 61000-4-2

Annex H (informative)

Documentation and information

A list of available standards applicable to documentation and information is provided in Table H.1.

Brief definitions of a set of internationally standardized document kinds are given in the publicly available database IEC 61355 DB (<http://std.iec.ch/iec61355>).

Table H.1 – Documentation and information that can be applicable

Type of information for the electrical equipment	Reference standard
Structuring principles	IEC 81346-1, Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 1: Basic rules
Structuring of documents	IEC 62023, Structuring of technical information and documentation ^a
Parts list	IEC 62027, Preparation of object lists, including parts lists
List of documents	IEC 62027, Preparation of object lists, including parts lists
Specification of the properties of the electrical equipment	IEC PAS 62569-1, Generic specification of information on products by properties – Part 1: Principles and methods
Instructions for handling, transportation and storage	IEC/IEEE 82079-1, Preparation of information for use (instructions for use) of products – Structuring, content and presentation – Part 1: Principles and general requirements
Instructions for installation, erection, assembling on site, dismantling, etc.	IEC/IEEE 82079-1, Preparation of information for use (instructions for use) of products – Structuring, content and presentation – Part 1: Principles and general requirements
Instructions for use	IEC/IEEE 82079-1, Preparation of information for use (instructions for use) of products – Structuring, content and presentation – Part 1: Principles and general requirements
Instructions for service and maintenance	IEC/IEEE 82079-1, Preparation of information for use (instructions for use) of products – Structuring, content and presentation – Part 1: Principles and general requirements
Reference designations	IEC 81346-1, Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 1: Basic rules and IEC 81346-2, Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 2: Classification of objects and codes for classes
Terminal designations	IEC 61666, Industrial systems, installations and equipment and industrial products – Identification of terminals within a system
Designations of cables and cores	IEC 62491, Industrial systems, installations and equipment and industrial products – Labelling of cables and cores
Circuit diagrams	IEC 61082-1, Preparation of documents used in electrotechnology – Part 1: Rules
Layout of equipment and overall dimensions	IEC 61082-1, Preparation of documents used in electrotechnology – Part 1: Rules
Interconnection diagram, terminal list, cable list, cable tray layout	IEC 61082-1, Preparation of documents used in electrotechnology – Part 1: Rules
Spare parts list for a specified period	IEC 62027, Preparation of object lists, including parts lists
List of parameters (e.g. of converters)	(No standard exists)

Type of information for the electrical equipment	Reference standard
List of tools	IEC/IEEE 82079-1, Preparation of information for use (instructions for use) of products – Structuring, content and presentation – Part 1: Principles and general requirements
Identification systems	IEC 62507-1, Identification systems enabling unambiguous information interchange – Requirements – Part 1: Principles and methods
^a For simple equipment, IEC 62023 allows all information to be contained within a single document.	

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IEC 60228, *Conductors of insulated cables*

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

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

**SÉCURITÉ DES MACHINES –
ÉQUIPEMENT ÉLECTRIQUE DES MACHINES –****Partie 32: Exigences pour les appareils de levage****AVANT-PROPOS**

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Cette troisième édition annule et remplace la deuxième édition parue en 2008. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

- a) L'alignement sur la sixième édition de l'IEC 60204-1 (2016) notamment pour:
 - les exigences relatives à la mise à la terre et à la liaison;
 - les exigences en matière de protection des circuits;
 - l'examen de l'utilisation des entraînements électriques de puissance (PDS);
 - les exigences et la terminologie relatives aux liaisons de protection;
 - les exigences relatives au couple de sécurité pour les PDS, l'arrêt d'urgence et la protection des circuits de commande;
 - les symboles des organes de commande des appareils de commande;
- b) la référence pour les équipements électriques à haute tension;
- c) les exigences relatives aux systèmes de commande sans fil;
- d) les exigences relatives à la CEM;
- e) les exigences en matière de documentation technique;
- f) la mise à jour générale des conditions spéciales nationales actuelles, des normes et des références bibliographiques.

Le texte de cette Norme internationale est issu des documents suivants:

Projet	Rapport de vote
44/1000/FDIS	44/1005/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

Ce document a été rédigé selon les directives ISO/IEC, Partie 2, il a été développé selon les directives ISO/IEC, Partie 1 et les directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/standardsdev/publications.

Les différentes pratiques suivantes, à caractère moins permanent, existent dans les pays indiqués ci-après:

- 4.3.1: Les caractéristiques de la tension de l'électricité fournie par les schémas de distribution publique en Europe sont indiquées dans l'EN 50160:2010.
- 5.1: L'exception n'est pas admise (USA).
- 5.1: Les schémas TN-C ne sont pas admis dans les installations à basse tension des bâtiments (Norvège).
- 5.2: Les bornes pour le raccordement des conducteurs de mise à la terre de protection peuvent être identifiées par la couleur verte, les lettres "G" ou "GR" ou "GRD" ou "GND", ou le mot "terre" ou "mise à la terre", ou avec le symbole graphique IEC 60417-519:2002-10 ou toute combinaison (USA).
- 5.3.1: Le sectionnement du conducteur neutre est obligatoire en schéma TN (Norvège).
- 6.3.3 b),
- 13.4.5 b),
- 18.2.1: Les schémas d'alimentation TT ne sont pas admis (USA).
- 6.3.3,
- 18.2,

Annexe A: Les schémas TN ne sont pas utilisés. Les schémas TT sont la norme nationale (Japon).

6.3.3 b) L'utilisation de dispositifs différentiels résiduels dont le courant différentiel de fonctionnement assigné ne dépasse pas 1 A est obligatoire dans les schémas TT comme moyen de protection contre les défauts par déconnexion automatique de l'alimentation (Italie).

7.2.3: La coupure du conducteur neutre est obligatoire en schéma TN-S (France).

7.2.3: Troisième alinéa: la distribution d'un conducteur neutre avec un schéma IT n'est pas admise (USA et Norvège).

7.10: Pour l'évaluation des caractéristiques assignées de court-circuit, les exigences de l'UL 508A Supplement SB, peuvent être utilisées (USA).

8.2.2: Voir l'IEC 60364-5-54:2011, Annexe E Liste des notes concernant certains pays. La tension nominale maximale du circuit de commande en courant alternatif est de 120 V (USA).

9.1.2: Seuls les fils torsadés sont admis sur les machines, à l'exception des conducteurs solides de 0,2 mm² à l'intérieur des enveloppes (USA).

12.2: Le plus petit conducteur du circuit de puissance admis sur les machines est de 0,82 mm² (AWG 18).

Tableau 5: Les sections sont spécifiées en NFPA 79 en utilisant l'AWG (American Wire Gauge) (USA). Voir l'Annexe F.

13.2.2: Pour le conducteur de protection, la couleur VERT (avec ou sans bandes JAUNE) est utilisée comme équivalent de la combinaison VERT-et-JAUNE (USA et Canada).

13.2.3: Les couleurs BLANC et GRIS sont utilisées pour les conducteurs de neutre mis à la terre au lieu du BLEU (USA et Canada).

15.2.2: Premier alinéa: Valeur maximale entre les conducteurs 150 V (USA).

15.2.2: Deuxième alinéa, cinquième point: La caractéristique assignée de courant de pleine charge des circuits d'éclairage ne dépasse pas 15 A (USA).

16.4: Exigences de marquage de la plaque signalétique (USA).

A.2.2.2: La valeur maximale admissible de R_A est régulée (par exemple, lorsque $U_0 > 300$ V, R_A doit être inférieur à 10 Ω lorsque $U_0 < 300$ V, R_A doit être inférieur à 100 Ω , U_0 est la tension phase-terre nominale en courant alternatif en volts (V) (Japon)).

A.2.2.2: La valeur maximale admissible de R_A est de 83 Ω (Pays-Bas).

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INTRODUCTION

La présente partie de l'IEC 60204 fournit les exigences et recommandations relatives à l'équipement électrique des appareils de levage en vue d'améliorer

- la sécurité des personnes et des biens;
- la cohérence de réponse des commandes;
- la facilité d'utilisation et de la maintenance.

Il est important que des performances élevées ne soient pas obtenues au détriment des paramètres essentiels mentionnés ci-dessus.

Les Figure 1 et Figure 2 sont fournies en tant qu'aide pour la compréhension des relations entre les différents éléments d'un appareil de levage et ses équipements associés. La Figure 1 représente le schéma d'ensemble d'un système de manutention typique (un groupe d'engins de levage fonctionnant de manière coordonnée) et la Figure 2 représente le schéma d'un appareil de levage type et ses équipements associés qui présentent les différents éléments de l'équipement électrique explicités dans le présent document.

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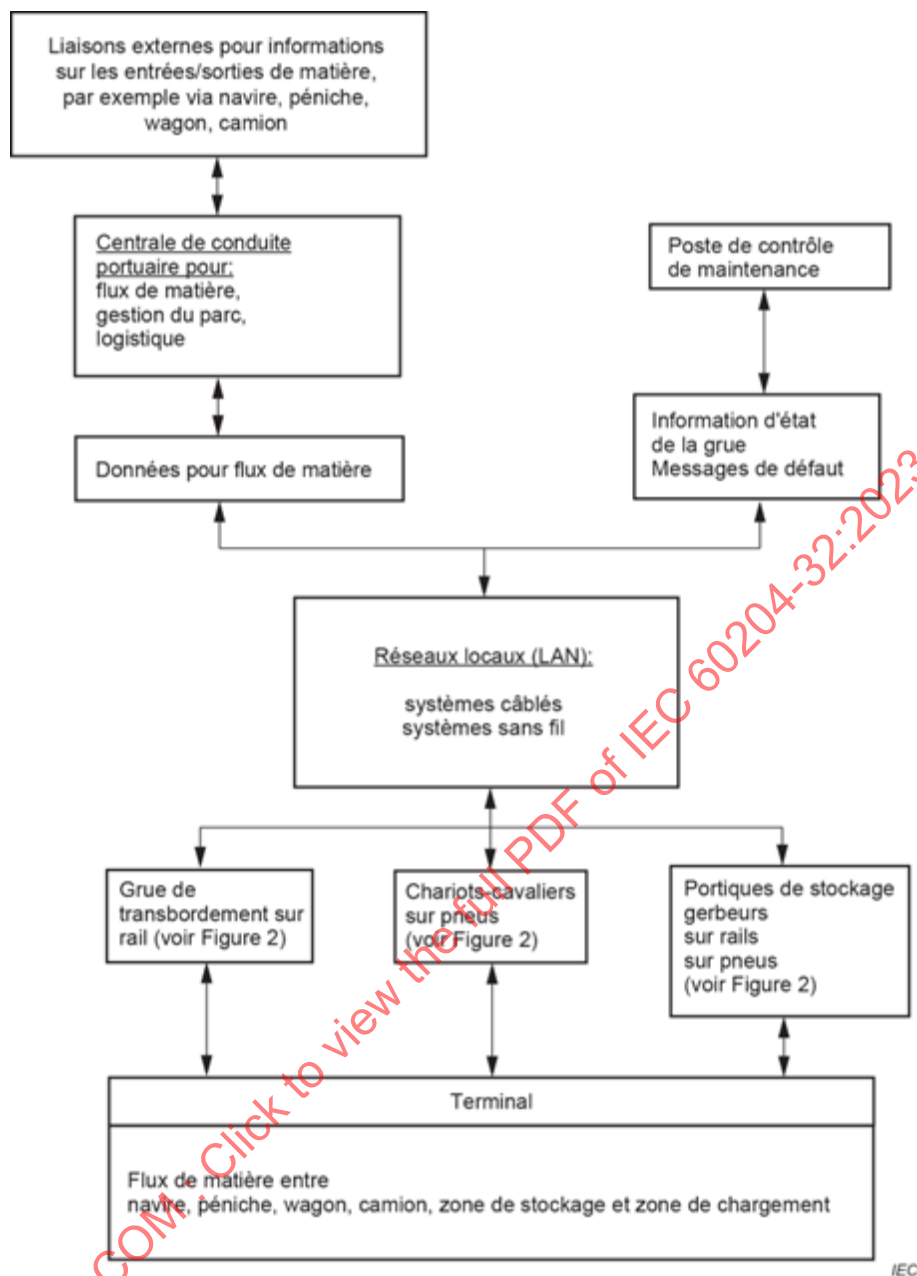
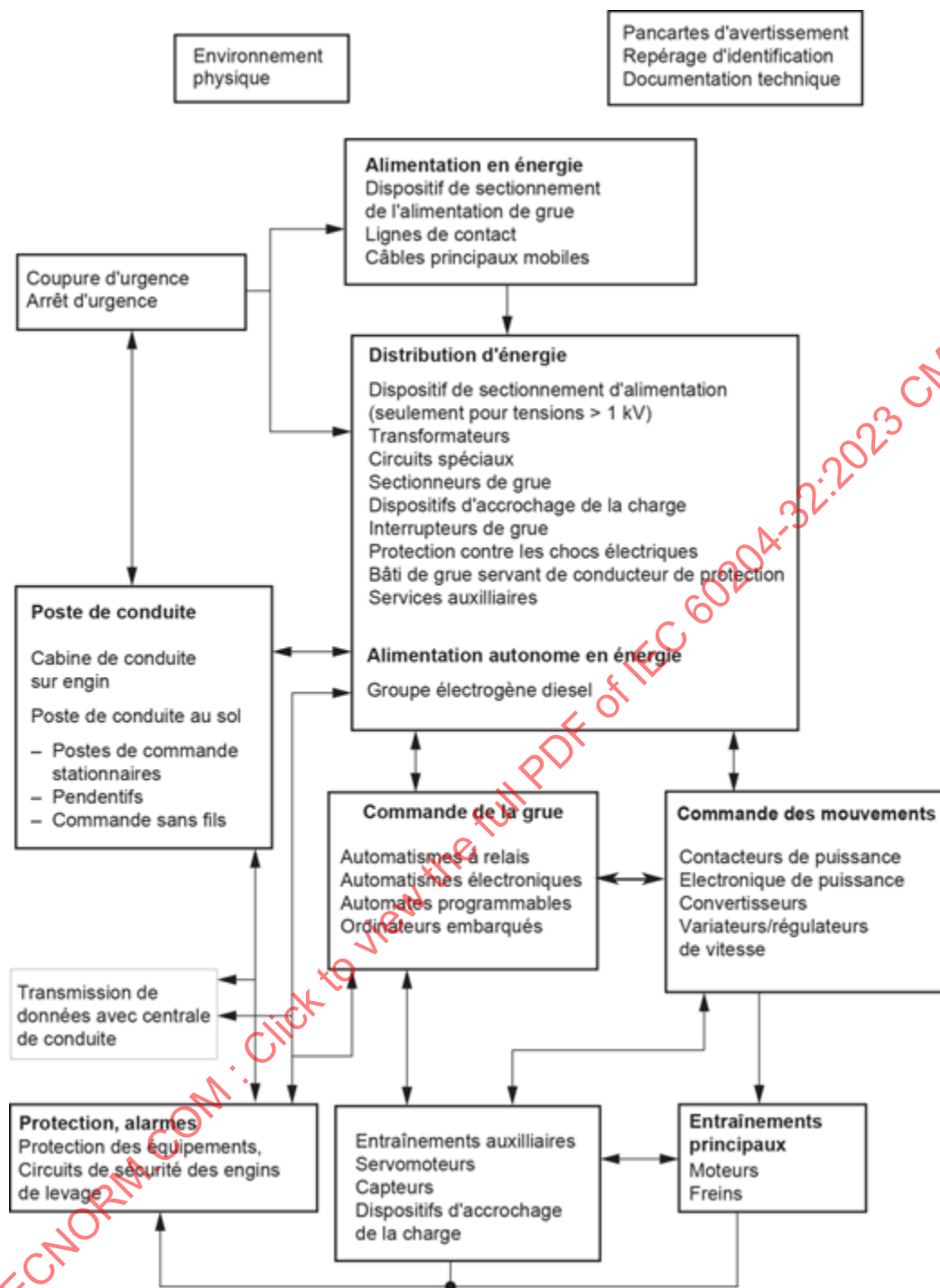


Figure 1 – Schéma fonctionnel d'appareils de levage associés dans un système type de manutention portuaire



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Figure 2 – Schéma fonctionnel d'un appareil de levage type et son équipement électrique associé

SÉCURITÉ DES MACHINES – ÉQUIPEMENT ÉLECTRIQUE DES MACHINES –

Partie 32: Exigences pour les appareils de levage

1 Domaine d'application

La présente partie de l'IEC 60204 s'applique aux équipements et systèmes électriques, électroniques et électroniques programmables des appareils de levage et à leurs équipements associés, y compris un groupe d'appareils de levage travaillant ensemble de manière coordonnée.

NOTE 1 Dans le présent document, le terme "électrique" est utilisé dans le sens général d'électrique et d'électronique (par exemple, "équipement électrique" concerne à la fois l'équipement électrique, l'équipement électronique et l'équipement électronique programmable).

NOTE 2 Dans le cadre du présent document, le terme "personne" s'applique à tout individu et comprend les personnes désignées et formées par l'utilisateur ou son ou ses agents pour l'utilisation et l'entretien de la machine de levage concernée.

L'équipement traité dans le présent document a pour origine le point de connexion de l'alimentation à l'équipement électrique de l'appareil de levage (sectionneur d'alimentation de l'appareil de levage), y compris l'alimentation de puissance et les alimentations de commande situées à l'extérieur de l'appareil de levage, par exemple, les câbles souples, les câbles conducteurs ou les barres conductrices (voir la Figure 3).

NOTE 3 Les exigences relatives à l'installation électrique de l'équipement électrique d'un appareil de levage sont données dans l'IEC 60364.

Le présent document s'applique aux équipements ou parties d'équipements dont la tension n'excède pas 1 000 V en courant alternatif et 1 500 V en courant continu entre phases, et dont la fréquence nominale n'excède pas 200 Hz.

NOTE 4 Des exigences spéciales pour l'équipement électrique des appareils de levage destinés à être utilisés à des tensions plus élevées sont fournies dans l'IEC 60204-11.

Le présent document ne couvre pas toutes les exigences (par exemple, la protection, le verrouillage ou la commande) qui sont nécessaires ou exigées par d'autres normes ou règlements afin de protéger les personnes contre les dangers autres que les dangers électriques. Chaque type d'appareil de levage a des exigences uniques auxquelles il faut répondre pour assurer une sécurité adéquate. Le présent document ne couvre pas les risques liés au bruit.

Des exigences complémentaires et particulières peuvent s'appliquer aux équipements électriques des appareils de levage, y compris ceux qui:

- manipulent ou transportent des matériaux potentiellement explosifs (par exemple, de la peinture ou de la sciure);
- sont destinés à être utilisés dans des atmosphères potentiellement explosives et/ou inflammables;
- présentent des risques particuliers lors du transport ou du déplacement de certains matériaux;
- sont destinés à être utilisés dans des mines.

Pour les besoins du présent document, les appareils de levage comprennent les grues de tous types, les treuils de tous types et les machines de stockage et d'extraction. Les familles de produits suivantes sont incluses:

- ponts roulants;
- grues mobiles;
- grues à tour;
- grues pivotantes à flèche relevable;
- portiques;
- grues offshore;
- grues flottantes;
- treuils de tous types;
- palans et accessoires;
- grues de chargement;
- grues à câble (blondins);
- accessoires de suspension de charge;
- machines de stockage et d'extraction;
- treuils suspendus avec rail de translation fixe;
- enjambeurs;
- portiques sur pneus.

NOTE 5 Des définitions des différents types de grues sont fournies dans l'ISO 4306-1.

Le présent document ne traite pas les éléments particuliers de l'équipement électrique, sauf pour leur choix et leur mise en œuvre.

2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60034-1:2017, *Machines électriques tournantes – Partie 1: Caractéristiques assignées et caractéristiques de fonctionnement*

IEC 60034-5, *Machines électriques tournantes – Partie 5: Degrés de protection procurés par la conception intégrale de machines électriques tournantes (code IP) – Classification*

IEC 60034-11, *Machines électriques tournantes – Partie 11: Protection thermique*

IEC 60068-2-27:2008, *Essais d'environnement – Partie 2-27: Essais – Essai Ea et guide: Chocs*

IEC 60068-2-31:2008, *Essais d'environnement – Partie 2-31: Essais – Ec: Choc lié à des manutentions brutales, essai destiné en premier lieu aux matériels*

IEC 60072-1, *Machines électriques tournantes – Dimensions et séries de puissances – Partie 1: Désignation des carcasses entre 56 et 400 et des brides entre 55 et 1 080*

IEC 60072-2, *Dimensions et séries de puissances des machines électriques tournantes – Partie 2: Désignation des carcasses entre 355 et 1000 et des brides entre 1 180 et 2 360*

IEC 60072-3, *Dimensions et séries de puissances des machines électriques tournantes – Partie 3: Petits moteurs incorporés – Désignation des brides BF10 à BF50*

IEC 60073:2002, *Principes fondamentaux et de sécurité pour l'interface homme-machine, le marquage et l'identification – Principes de codage pour les indicateurs et les organes de commande*

IEC 60309-1, *Fiches, socles fixes de prise de courant, prises mobiles et socles de connecteur pour usages industriels – Partie 1: Exigences générales*

IEC 60364-1:2005, *Installations électriques à basse tension – Partie 1: Principes fondamentaux, détermination des caractéristiques générales, définitions*

IEC 60364-4-41:2005, *Installations électriques à basse tension – Partie 4-41: Protection pour assurer la sécurité – Protection contre les chocs électriques.*

IEC 60364-4-41:2005/AMD1:2017

IEC 60364-4-43:2008, *Installations électriques à basse tension – Partie 4-43: Protection pour assurer la sécurité – Protection contre les surintensités*

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IEC 60445:2021, *Principes fondamentaux et de sécurité pour les interfaces homme-machines, le marquage et l'identification – Identification des bornes de matériels, des extrémités de conducteurs et des conducteurs*

IEC 60447:2004, *Principes fondamentaux et de sécurité pour l'interface homme-machine, le marquage et l'identification – Principes de manœuvre*

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IEC 60664-1, *Coordination de l'isolement des matériels dans les réseaux d'énergie électrique à basse tension – Partie 1: Principes, exigences et essais*

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IEC 60947-1, *Appareillage à basse tension – Partie 1: Règles générales*

IEC 60947-2:2016, *Appareillage à basse tension – Partie 2: Disjoncteurs*

IEC 60947-3, *Appareillage à basse tension – Partie 3: Interrupteurs, sectionneurs, interrupteurs-sectionneurs et combinés-fusibles*

IEC 60947-4-1:2018, *Appareillage à basse tension – Partie 4-1: Contacteurs et démarreurs de moteurs – Contacteurs et démarreurs électromécaniques*

IEC 60947-5-1:2016, *Appareillage à basse tension – Partie 5-1: Appareils et éléments de commutation pour circuits de commande – Appareils électromécaniques pour circuits de commande*

IEC 60947-5-5, *Appareillage à basse tension – Partie 5-2: Appareils et éléments de commutation pour circuits de commande – Appareil d'arrêt d'urgence électrique à accrochage mécanique*

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IEC 61310 (toutes les parties), *Sécurité des machines – Indication, marquage et manœuvre*

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IEC 61557-3, *Sécurité électrique dans les réseaux de distribution basse tension au plus égale à 1 000 V c.a. et 1 500 V c.c – Dispositifs de contrôle, de mesure ou de surveillance de mesures de protection – Partie 3: Impédance de boucle*

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IEC 61558-1, *Sécurité des transformateurs, bobines d'inductance, blocs d'alimentation et des combinaisons de ces éléments – Partie 1: Exigences générales et essais*

IEC 61558-2-2, *Sécurité des transformateurs, bobines d'inductance, blocs d'alimentation et combinaisons de ces éléments – Partie 2-2: Exigences particulières et essais pour les transformateurs de commande et les alimentations incorporant les transformateurs de commande*

IEC 61558-2-6, *Safety of transformers, reactors, power supply units and combinations thereof – Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers for general applications* (disponible en anglais seulement)

IEC 61558-2-16, *Sécurité des transformateurs, bobines d'inductance, blocs d'alimentation et combinaisons de ces éléments – Partie 2-16: Exigences particulières et essais pour les blocs d'alimentation à découpage et les transformateurs pour blocs d'alimentation à découpage pour applications d'ordre général*

IEC 61800-3, *Entraînements électriques de puissance à vitesse variable – Partie 3: Exigences de CEM et méthodes d'essai spécifiques pour les PDS et machines-outils*

IEC 61800-5-1, *Entraînements électriques de puissance à vitesse variable – Partie 5-1: Exigences de sécurité – Électrique, thermique et énergétique IEC*

IEC 61800-5-2, *Entraînements électriques de puissance à vitesse variable – Partie 5-2: Exigences de sécurité – Fonctionnelle*

IEC 61984, *Connecteurs – Exigences de sécurité et essais*

IEC 62023, *Structuration des informations et de la documentation techniques*

IEC 62061, *Sécurité des machines – Sécurité fonctionnelle des systèmes de commande relatifs à la sécurité*

IEC 62745:2017, *Sécurité des machines – Exigences pour les systèmes de commande sans fil des machines*

ISO 7010, *Symboles graphiques – Couleurs de sécurité et signaux de sécurité – Signaux de sécurité enregistrés*, disponible à l'adresse <https://www.iso.org/obp>

ISO 12100:2010, *Sécurité des machines – Principes généraux de conception – Appréciation du risque et réduction du risque*

ISO 13849-1, *Sécurité des machines – Parties des systèmes de commande relatives à la sécurité – Partie 1: Principes généraux de conception*

ISO 13849-2, *Sécurité des machines – Parties des systèmes de commande relatives à la sécurité – Partie 2: Validation*

ISO 13850:2015, *Sécurité des machines – Fonction d'arrêt d'urgence – Principes de conception*

ISO 13857, *Sécurité des machines – Distances de sécurité empêchant les membres supérieurs et inférieurs d'atteindre les zones dangereuses*

3 Termes, définitions et abréviations

3.1 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse <https://www.electropedia.org/>;
- ISO Online browsing platform: disponible à l'adresse <http://www.iso.org/obp>.

3.1.1

organe de commande

partie d'un appareil à laquelle une action manuelle extérieure doit être appliquée

Note 1 à l'article: L'organe de commande peut prendre la forme d'une poignée, d'un bouton, d'un bouton-poussoir, d'une roulette, d'un plongeur, etc.

Note 2 à l'article: Certains organes n'exigent pas d'effort extérieur, mais seulement une action, par exemple les écrans tactiles.

Note 3 à l'article: Voir également 3.1.53.

3.1.2

température ambiante

température de l'air ou d'un autre milieu dans lequel le matériel doit être utilisé

3.1.3

appareil

dispositif fini ou combinaison de dispositifs disponibles mis sur le marché en une seule unité fonctionnelle, destiné à l'utilisateur final et susceptible de produire des perturbations électromagnétiques, ou dont le fonctionnement est susceptible d'être affecté par de telles perturbations

3.1.4

barrière

partie assurant la protection, dans toute direction habituelle d'accès, contre tout contact par un être humain ou un animal avec les parties actives dangereuses

[SOURCE: IEC 60050-195:2021, 195-06-15, modifié – Le terme "barrière de protection" a été remplacé par "barrière".]

3.1.5

module d'entraînement principal

BDM

convertisseur électronique de puissance et commande associée, connecté entre une source d'alimentation électrique et un moteur

Note 1 à l'article: L'abréviation "BDM" est dérivée du terme anglais développé correspondant "basic drive module".

[SOURCE: IEC 61800-2:2021, 3.4]

3.1.6

protection principale

protection contre les chocs électriques dans des conditions normales

Note 1 à l'article: Appelé auparavant "protection contre les contacts directs".

[SOURCE: IEC 60050-195:1998, 195-06-01, modifié – La note à l'article a été ajoutée.]

3.1.7

appareil de levage commandé par cabine

appareil de levage commandé à partir d'une cabine fixée de manière permanente à l'appareil de levage

3.1.8

chemin de câbles

support de câbles constitué d'une base continue avec des rebords, mais ne comportant pas de couvercle

Note 1 à l'article: Un chemin de câbles peut être perforé ou en treillis.

[SOURCE: IEC 60050-826:2022, 826-15-08]

3.1.9

système de goulottes

ensemble d'enveloppes fermées, munies d'un fond avec un couvercle amovible et destiné à la protection complète des conducteurs isolés et des câbles et/ou au logement d'autres matériels électriques y compris des matériels de traitement de l'information

[SOURCE: IEC 60050-826:2022, 826-15-04]

3.1.10

concomitant

<deux ou plusieurs appareils de commande> actifs en même temps, mais pas nécessairement de manière synchrone

3.1.11**fil conducteur**
barre conductrice
rail conducteur

fil, rail conducteur ou barre conductrice d'un réseau d'alimentation avec collecteur de courant coulissant

3.1.12**conduit**

élément d'un système de canalisation électrique fermé de section droite généralement circulaire, destiné à la mise en place par tirage ou au remplacement des conducteurs et/ou des câbles isolés dans les installations électriques ou de télécommunication

Note 1 à l'article: Il convient que les conduits soient suffisamment fermés sur leur pourtour de façon que les conducteurs isolés ne puissent être introduits que par tirage et non par insertion latérale.

[SOURCE: IEC 60050-826:2022, 826-15-03]

3.1.13**circuit de commande**

<d'un appareil de levage> circuit utilisé pour la commande, y compris la surveillance, d'un appareil de levage et de l'équipement électrique

3.1.14**appareil de commande**

appareil raccordé au circuit de commande et qui sert à commander le fonctionnement de l'appareil de levage (par exemple, détecteurs de position, auxiliaires manuels de commande, relais, électrodistributeurs, capteurs de vitesse)

3.1.15**appareillage de commande**

terme général applicable aux appareils de connexion et à leur combinaison avec des appareils de commande, de mesure, de protection et de réglage qui leur sont associés, ainsi qu'aux ensembles de tels appareils avec les connexions, les accessoires, les enveloppes et les supports correspondants, destinés en principe à la commande des appareils utilisateurs d'énergie électrique

[SOURCE: IEC 60050-441:1984, 441-11-03]

3.1.16**poste de commande****poste de commande opérateur**

ensemble constitué par un ou plusieurs organes de commande fixés sur le même panneau ou situés dans la même enveloppe

Note 1 à l'article: Un poste de commande peut aussi contenir des appareils associés, par exemple: potentiomètres, lampes de signalisation, appareils de mesure, dispositifs d'affichage, etc.

Note 2 à l'article: Une définition du terme "organe" est donnée au 3.1.1.

3.1.17**arrêt contrôlé**

arrêt du mouvement d'un appareil de levage, en maintenant la puissance électrique aux actionneurs durant la procédure d'arrêt

3.1.18**grue**

appareil pour monter/descendre et déplacer horizontalement des charges suspendues

3.1.19

sectionneur de grue

sectionneur manuel installé sur un appareil de levage pour la déconnexion (sectionnement) du circuit d'alimentation (par exemple, pour des réparations ou des travaux d'entretien)

3.1.20

interrupteur d'alimentation de grue

appareil de sectionnement et de connexion utilisé pour déconnecter l'appareil de levage de son alimentation

3.1.21

interrupteur de grue

appareil de connexion destiné à couper l'alimentation de puissance des entraînements connectés (par exemple, dans le cas d'une coupure d'urgence)

3.1.22

courant admissible

valeur maximale du courant électrique qui peut parcourir en permanence, un conducteur, un dispositif ou un appareil, sans que sa température de régime permanent, dans des conditions données, soit supérieure à la valeur spécifiée

[SOURCE: IEC 60050-826:2022, 826-11-13]

3.1.23

contact direct

contact électrique d'êtres humains ou d'animaux avec des parties actives

[SOURCE: IEC 60050-195:2021, 195-06-03.]

3.1.24

manœuvre positive d'ouverture

<élément de contact> accomplissement de la séparation des contacts résultant directement d'un mouvement de l'organe de commande et effectué au moyen de pièces non élastiques (par exemple sans l'intermédiaire de ressorts)

[SOURCE: IEC 60947-5-1:2016, K.2.2]

3.1.25

appareil de sectionnement

appareil qui assure, en position d'ouverture, une distance de sectionnement satisfaisant à des exigences spécifiées

3.1.26

canalisation

canal fermé destiné expressément au support et à la protection de conducteurs, de câbles et de barres électriques

Note 1 à l'article: Les conduits (3.1.12), les systèmes de goulottes (3.1.9) et les canaux enterrés sont des types de canalisations.

3.1.27

terre

terre locale

partie de la Terre en contact électrique avec une prise de terre, et dont le potentiel électrique n'est pas nécessairement égal à zéro

[SOURCE: IEC 60050-195:2021, 195-01-03, modifié – Le terme "terre" a été ajouté.]

3.1.28**zone de service électrique**

local ou emplacement pour matériels électriques dont l'accès est destiné à être restreint aux personnes qualifiées ou averties, par ouverture d'une porte ou retrait d'une barrière, sans l'aide d'une clé ou d'un outil et qui est clairement marqué à l'aide de signaux d'avertissement appropriés

3.1.29**équipement électronique**

partie d'un équipement électrique qui comprend des circuits dont le fonctionnement dépend de dispositifs et composants électroniques

3.1.30**dispositif d'arrêt d'urgence**

appareil de commande manœuvré manuellement et utilisé pour initier une fonction d'arrêt d'urgence

[SOURCE: ISO 13850-2015, 3.3]

3.1.31**appareil de coupure d'urgence**

appareil de commande manœuvré manuellement et destiné à couper l'alimentation électrique de tout ou partie d'une installation s'il y a risque de choc électrique ou tout autre risque d'origine électrique

3.1.32**zone fermée de service électrique**

local ou emplacement de matériels électriques dont l'accès est destiné à être restreint aux personnes qualifiées ou averties par ouverture d'une porte ou retrait d'une barrière à l'aide d'une clé ou d'un outil et qui est clairement marqué à l'aide de signaux d'avertissement appropriés

3.1.33**enveloppe**

élément qui assure la protection des matériels contre certaines influences externes et, dans toutes les directions, la protection contre les contacts directs

Note 1 à l'article: Cette définition tirée du VEI existant nécessite les explications suivantes dans le cadre du présent document.

- a) les enveloppes assurent la protection de personnes ou d'animaux domestiques ou d'élevage contre l'accès aux parties dangereuses.
- b) Les barrières, formes des ouvertures, ou tous les autres moyens appropriés pour prévenir ou limiter la pénétration des calibres d'essai spécifiés, soit fixés sur l'enveloppe, soit formés par l'appareillage sous enveloppe, sont considérés comme faisant partie de l'enveloppe, sauf s'ils peuvent être démontés sans l'aide d'une clé ou d'un outil.
- c) Une enveloppe peut être:
 - une armoire ou un coffret, monté(e) sur l'appareil de levage, ou séparé(e) de l'appareil de levage;
 - un compartiment, constitué par un espace clos dans la structure de l'appareil de levage (par exemple, la poutre principale).

3.1.34**équipement électrique**

éléments utilisés dans le cadre d'une installation électrique par les machines ou des parties de machines, par exemple, matériel, accessoires, dispositifs, composants, appareils, fixations, instruments et analogues

3.1.35

liaison équipotentielle

ensemble de liaisons électriques pour réaliser l'équipotentialité entre parties conductrices

[SOURCE: IEC 60050-195:2021, 195-01-10]

3.1.36

partie conductrice accessible

partie conductrice d'un matériel, susceptible d'être touchée, et qui n'est pas sous tension dans des conditions normales, mais peut le devenir lorsque l'isolation principale est défailante

[SOURCE: IEC 60050-195:2021, 195-06-10]

3.1.37

élément conducteur étranger

partie conductrice ne faisant pas partie de l'installation électrique et susceptible d'introduire un potentiel électrique, généralement celui d'une terre locale

[SOURCE: IEC 60050-195:2021, 195-06-11]

3.1.38

défaillance

cessation de l'aptitude d'une entité à accomplir une fonction exigée

Note 1 à l'article: Après défaillance, l'entité est en état de panne.

Note 2 à l'article: Une défaillance est un passage d'un état à un autre, par opposition à une panne, qui est un état.

Note 3 à l'article: Ce concept tel qu'il est défini, ne s'applique pas à des entités constituées seulement de logiciels.

Note 4 à l'article: En pratique, les termes "défaut" et "défaillance" sont souvent utilisés comme synonymes.

[SOURCE: IEC 60050-845:2020, 845-27-105, modifié – Une quatrième note à l'article a été ajoutée.]

3.1.39

défaut

état d'une entité inapte à accomplir une fonction exigée, à l'exclusion de son inaptitude due à la maintenance préventive ou à d'autres actions programmées, ou due à un manque de moyens extérieurs

Note 1 à l'article: Un défaut est souvent la conséquence d'une défaillance de l'entité elle-même, mais il peut exister sans défaillance préalable.

3.1.40

protection en cas de défaut

protection contre les chocs électriques dans des conditions de premier défaut

Note 1 à l'article: Appelée précédemment "protection contre les contacts indirects".

[SOURCE: IEC 60050-195:2021, 195-06-02, modifié – Une note à l'article a été ajoutée.]

3.1.41

premier environnement

environnement qui comprend des lieux à usage domestique, ou dont l'alimentation électrique est directement fournie sans transformateur intermédiaire, par un réseau public basse tension qui alimente aussi des bâtiments à usage domestique

Note 1 à l'article: Les maisons, appartements, bâtiments commerciaux ou bureaux dans des immeubles résidentiels sont des exemples de locaux du premier environnement.

3.1.42**installation fixe**

combinaison particulière de plusieurs types d'appareils et, le cas échéant, d'autres dispositifs, qui sont assemblés, installés et destinés à être utilisés de façon permanente sur un emplacement prédéfini

3.1.43**liaison fonctionnelle**

liaison équipotentielle nécessaire au fonctionnement correct de l'équipement électrique

3.1.44**protecteur**

élément d'un appareil de levage spécifiquement utilisé pour assurer une protection par une barrière physique

3.1.45**dispositif portable à commande directe**

appareil de connexion à commande manuelle dont l'enveloppe est portable à la main pendant le fonctionnement, qui agit directement sur le circuit de puissance de l'appareil de levage

3.1.46**phénomène dangereux**

source potentielle de dommage

Note 1 à l'article: L'expression "phénomène dangereux" peut être qualifié de manière à faire apparaître l'origine (par exemple, phénomène dangereux mécanique, phénomène dangereux électrique) ou la nature du dommage potentiel (par exemple phénomène dangereux de choc électrique, phénomène dangereux de coupure, phénomène dangereux d'intoxication, phénomène dangereux d'incendie).

Note 2 à l'article: Le phénomène dangereux envisagé dans cette définition est:

- soit présent en permanence pendant l'utilisation normale de la machine (par exemple, déplacement d'éléments mobiles dangereux, arc électrique pendant une phase de soudage, mauvaise posture, émission de bruit, température élevée);
- soit il peut apparaître de manière inattendue (par exemple: explosion, écrasement résultant d'une mise en fonctionnement intempestive ou inattendue, projection résultant d'une rupture, chute résultant d'une accélération ou d'une décélération).

[SOURCE: ISO 12100:2010, 3.6, modifié – La Note 3 a été supprimée.]

3.1.47**contact indirect**

contact électrique d'êtres humains ou d'animaux avec des parties conductrices accessibles mises sous tension à la suite d'un défaut

[SOURCE: IEC 60050-195:2021, 195-06-04]

3.1.48**système d'alimentation par induction**

système de transfert de puissance par induction qui comporte un dispositif convertisseur et un dispositif conducteur, le long desquels un ou plusieurs détecteurs ou convertisseurs détecteurs peuvent se déplacer, sans aucun contact galvanique ou mécanique, afin de transférer l'énergie électrique par exemple à un appareil de levage mobile

Note 1 à l'article: Le dispositif conducteur et le détecteur sont analogues respectivement à un primaire et un secondaire d'un transformateur.

3.1.49

personne avertie

personne avertie en électricité

personne suffisamment informée ou surveillée par des personnes qualifiées en électricité pour lui permettre de percevoir les risques et d'éviter les dangers que peut présenter l'électricité

[SOURCE: IEC 60050-195:2021, 195-04-02]

3.1.50

verrouillage

configuration de dispositifs qui interagissent pour:

- prévenir les situations dangereuses;
- prévenir tout dommage aux équipements ou matériaux;
- prévenir des manœuvres spécifiées;
- assurer des manœuvres correctes

3.1.51

dispositif limiteur

dispositif qui empêche une machine de levage ou l'un de ses éléments de dépasser une limite donnée (par exemple, limite dans l'espace, limite de pression, limite de charge, limite de moment de charge)

[SOURCE: ISO 12100 3.28.8, modifié – Dans la définition, "machine ou certains états dangereux de cette machine" a été remplacé par "machine de levage ou l'un de ses éléments" et "limite de charge" a été ajouté.]

3.1.52

partie active

partie conductrice destinée à être sous tension dans des conditions normales de fonctionnement, y compris le conducteur de neutre et le conducteur de point milieu, à l'exception toutefois du conducteur PEN, du conducteur PEM et du conducteur PEL

[SOURCE: IEC 60050-195:2021, 195-02-19]

3.1.53

actionneur

mécanisme de puissance utilisé pour animer l'appareil de levage (par exemple, moteur, solénoïde, cylindre pneumatique ou hydraulique)

3.1.54

machine

machine

ensemble de pièces ou d'organes liés entre eux, dont au moins un est mobile, auxquels sont associés, selon les besoins, des actionneurs, des circuits de commande et de puissance, réunis de façon solidaire en vue d'une application définie, notamment pour la transformation, le traitement, le déplacement et le conditionnement d'un matériau

Note 1 à l'article: Le terme "machine" désigne aussi un ensemble de machines qui, afin de concourir à un même résultat, sont disposées et commandées de manière à être solidaires dans leur fonctionnement.

Note 2 à l'article: Le terme "composant" est employé dans le cas présent au sens général et il ne fait pas seulement référence aux composants électriques.

3.1.55

appareil de levage commandé manuellement

appareil de levage avec commande manuelle directe continue de la charge, la charge étant visible en permanence par l'opérateur

3.1.56**marquage**

signes ou inscriptions utilisés en premier lieu pour les besoins d'identification du matériel, des composants et/ou des appareils

3.1.57**conducteur neutre****N**

conducteur relié électriquement au point neutre et capable de contribuer à la distribution de l'énergie électrique

[SOURCE: IEC 60050-195:2021, 195-02-06]

3.1.58**obstacle**

élément empêchant un contact direct fortuit d'un être humain ou d'un animal avec des parties actives, mais ne s'opposant pas à un tel contact par une action délibérée

[SOURCE: IEC 60050-195:2021, 195-06-16, modifié – Le terme "obstacle de protection, <électrique>" a été remplacé par "obstacle".]

3.1.59**surintensité**

courant électrique dont la valeur dépasse une valeur limite spécifique

[SOURCE: IEC 60050-151:2001, 151-15-28]

3.1.60**surcharge**

relation temps/courant dans un circuit supérieure à la pleine charge assignée du circuit lorsque ce dernier n'est pas en défaut

Note 1 à l'article: Il convient de ne pas utiliser le terme "surcharge" comme un synonyme de "surintensité".

Note 2 à l'article: Pour les appareils de levage, le terme "surcharge" est aussi utilisé pour une surcharge mécanique, laquelle peut entraîner ou non une surcharge électrique.

3.1.61**ensemble fiche-prise**

composant et composant adapté d'accouplement, approprié pour raccorder les conducteurs, destiné à la connexion et à la déconnexion de deux ou plusieurs conducteurs

Note 1 à l'article: Les ensembles fiche-prise comprennent par exemple:

- les prises mobiles qui satisfont aux exigences de l'IEC 61984;
- une prise de courant, un prolongateur ou un connecteur conformes à l'IEC 60309-1;
- une prise de courant conforme à l'IEC 60884-1, ou un connecteur conforme à l'IEC 60320-1.

3.1.62**circuit de puissance**

circuit qui transmet l'énergie du réseau aux éléments d'équipement utilisés directement pour le travail effectué par la machine et aux transformateurs qui alimentent les circuits de commande

3.1.63

entraînement électrique de puissance

PDS

système comprenant un ou plusieurs modules d'entraînement complets (CDM) avec un ou plusieurs moteurs

Note 1 à l'article: L'abréviation "PDS" est dérivée du terme anglais développé correspondant "power drive system".

[SOURCE: IEC 61800-2:2021, 3.52]

3.1.64

PDS de catégorie 1

PDS destiné à être utilisé dans le premier environnement

3.1.65

PDS de catégorie 2

PDS qui n'est ni un appareil avec cordon d'alimentation et prise, ni un appareil mobile, et qui, lorsqu'il est utilisé dans le premier environnement, est destiné à être installé et mis en service uniquement par un professionnel

Note 1 à l'article: Un professionnel est une personne ou une organisation qui possède les compétences nécessaires à l'installation et/ou la mise en service des systèmes d'entraînement de puissance, y compris pour leurs aspects CEM.

3.1.66

PDS de catégorie 3

PDS destiné à être utilisé dans le deuxième environnement et non destiné à être utilisé dans le premier environnement

3.1.67

PDS de catégorie 4

PDS de tension assignée égale ou supérieure à 1 000 V, ou de courant assigné égal ou supérieur à 400 A, ou destiné à être utilisé dans des systèmes complexes du deuxième environnement

3.1.68

liaison de protection

liaison équipotentielle destinée à la protection contre les chocs électriques

Note 1 à l'article: Les mesures destinées à protéger contre les chocs électriques peuvent aussi réduire le risque de brûlure ou d'incendie.

Note 2 à l'article: Les liaisons de protection peuvent être effectuées à l'aide de conducteurs de protection et de conducteurs de liaison de protection et en reliant par un conducteur les parties conductrices de la machine et de ses équipements électriques.

3.1.69

circuit de protection

ensemble des conducteurs de protection et des parties conductrices raccordés ensemble afin d'assurer la protection contre les chocs électriques en cas de défaut d'isolement

3.1.70

conducteur de protection

conducteur qui fournit un chemin de courant de défaut primaire depuis les parties conductrices accessibles de l'équipement électrique jusqu'à une borne de mise à la terre (PE) de protection

3.1.71

redondance

utilisation de plusieurs dispositifs ou systèmes, ou d'éléments d'un dispositif ou système, qui visent à garantir que si l'un d'eux est défaillant dans l'exécution de sa fonction, un autre est disponible pour exécuter ladite fonction

3.1.72**désignation de référence**

code distinct qui sert à identifier un élément dans la documentation et sur le matériel

3.1.73**risque**

combinaison de la probabilité d'un dommage et de la gravité de ce dommage

Note 1 à l'article: Le terme "dommage" se rapporte aux blessures physiques ou à l'atteinte à la santé.

[SOURCE: ISO 12100:2010, 3.12, modifié – La Note 1 à l'article a été ajoutée.]

3.1.74**protecteur de sécurité**

protecteur ou dispositif de protection utilisé comme mesure de sécurité pour protéger les personnes contre un danger

3.1.75**protection**

mesures de prévention faisant appel à des moyens de protection pour préserver les personnes des phénomènes dangereux qui ne peuvent raisonnablement être éliminés, ou des risques qui ne peuvent être suffisamment réduits, par l'application de mesures de prévention intrinsèque

[SOURCE: ISO 12100-2010, 3.21]

3.1.76**fonction de sécurité**

fonction d'une machine dont la défaillance peut provoquer un accroissement immédiat du (des) risque(s)

[SOURCE: ISO 12100:2010, 3.30]

3.1.77**deuxième environnement**

environnement qui comprend des lieux autres que ceux qui sont directement alimentés en électricité par un réseau public basse tension alimentant aussi des bâtiments à usage domestique

Note 1 à l'article: Les zones industrielles, les locaux techniques de tout immeuble alimenté à partir d'un transformateur spécifique sont des exemples de locaux du deuxième environnement.

3.1.78**plancher de service**

niveau sur lequel se trouvent les personnes qui interviennent pour l'entretien de l'équipement électrique

3.1.79**courant de court-circuit**

surintensité résultant d'un court-circuit dû à un défaut ou à un branchement incorrect dans un circuit électrique

[SOURCE: IEC 60050-441:1984, 441-11-07]

3.1.80**courant de court-circuit assigné**

valeur du courant de court-circuit présumé à laquelle un équipement électrique peut résister pendant la durée totale de fonctionnement (temps de coupure) d'un dispositif de protection contre les courts-circuits (DPCC) dans des conditions spécifiées

3.1.81

personne qualifiée

personne qualifiée en électricité

personne ayant la formation, l'éducation et l'expérience appropriées pour lui permettre de percevoir les risques et d'éviter les dangers que peut présenter l'électricité

[SOURCE: IEC 60050-195:2021, 195-04-01, modifié – La formation est une condition nécessaire supplémentaire.]

3.1.82

fournisseur

entité (par exemple, fabricant, maître d'œuvre, installateur, intégrateur) qui fournit l'appareillage ou les services associés à l'appareil de levage

Note 1 à l'article: L'organisme utilisateur peut aussi agir en tant que son propre fournisseur.

3.1.83

appareil de connexion

appareil destiné à établir et/ou à interrompre le courant dans un ou plusieurs circuits électriques

[SOURCE: IEC 60050-441:1984, 441-14-01, modifié – Dans la définition, "et/" a été ajouté.]

3.1.84

borne

partie d'un appareil ou d'un composant à laquelle un conducteur est fixé pour réaliser une connexion réutilisable

[SOURCE: IEC 60050-442:1998, 442-06-05, modifié – Dans la définition, "ou d'un composant" a été ajouté.]

3.1.85

arrêt non contrôlé

arrêt du mouvement d'un appareil de levage par suppression de la puissance électrique aux actionneurs

Note 1 à l'article: Cette définition ne nécessite pas que les autres dispositifs d'arrêt (par exemple, non électriques) soient dans un état particulier, par exemple les freins mécaniques ou hydrauliques, qui n'entrent pas dans le domaine d'application du présent document.

3.1.86

utilisateur

entité qui utilise l'appareil de levage et son équipement électrique associé

3.2 Abréviations

AWG	(American Wire Gauge) Calibre américain des fils
CA	Courant alternatif
BDM	(Basic Drive Module) Module d'entraînement principal
CCS	(Cableless Control System) Système de commande sans fil
DC	(Direct Current) Courant continu
CEM	Compatibilité électromagnétique
EMI	(Electro-Magnetic Interference) Brouillage électromagnétique
PDS	(Power Drive System) Entraînement électrique de puissance
TBTP	Très basse tension de protection
DDR	Dispositif différentiel résiduel
DPCC	Dispositif de protection contre les courts-circuits

eff	Valeur efficace
TBTS	Très basse tension de sécurité
STO	(Safe Torque Off) Suppression sûre du couple

4 Exigences générales

4.1 Considérations générales

Le présent document est destiné à être appliqué aux équipements électriques utilisés avec une grande variété d'appareils de levage et avec un groupe d'appareils de levage travaillant ensemble de façon coordonnée.

Les risques associés aux dangers relatifs à l'équipement électrique doivent être estimés comme un élément des exigences globales pour l'appréciation du risque de l'appareil de levage. Ceci

- identifie la nécessité d'une réduction du risque; et
- détermine les réductions de risque adéquates; et
- détermine les mesures de protection nécessaires;

pour les personnes potentiellement exposées à ces dangers, tout en conservant des performances appropriées à l'appareil de levage et à ses équipements.

Les situations dangereuses peuvent être dues, entre autres, à:

- des défaillances ou des défauts de l'équipement électrique qui conduisent à la possibilité de choc électrique ou de feu d'origine électrique;
- des défaillances ou des défauts dans les circuits de commande (ou les composants ou dispositifs associés à ces circuits) qui conduisent à un dysfonctionnement de l'appareil de levage;
- des variations ou interruptions dans les sources d'alimentation ainsi que les défaillances ou des défauts des circuits de puissance qui conduisent à un dysfonctionnement de l'appareil de levage;
- une perte de continuité dans les circuits, par exemple, les circuits qui dépendent de contacts glissants ou roulants, qui peut conduire à une défaillance d'une fonction de sécurité;
- des perturbations électriques, par exemple, des perturbations électromagnétiques, électrostatiques, générées de façon soit interne soit externe à l'équipement électrique, qui conduisent à un dysfonctionnement de l'appareil de levage;
- une libération d'énergie accumulée (électrique ou mécanique) qui conduit à, par exemple, un choc électrique, un mouvement inattendu, pouvant provoquer une blessure;
- un bruit acoustique et des vibrations mécaniques d'un niveau tel qu'ils provoquent des problèmes de santé aux personnes;
- des températures de surfaces qui peuvent provoquer des blessures.

Les mesures de sécurité associent les mesures prises à l'étape de la conception et celles dont la mise en œuvre par l'utilisateur est exigée.

Le processus de conception et de développement doit identifier les dangers et les risques induits. Lorsque les dangers ne peuvent être éliminés et/ou lorsque les risques ne peuvent être suffisamment réduits par l'application de mesures de prévention intrinsèque, des mesures de protection (par exemple, la protection par protecteur) doivent être fournies pour réduire le risque. Des moyens supplémentaires (par exemple, des moyens de sensibilisation, des feux clignotants, des notices ou des signaux d'avertissement pour élever la prise de conscience des risques) doivent être fournis si une réduction du risque supplémentaire est nécessaire. De plus, des procédures de travail qui réduisent le risque peuvent être nécessaires.

Il est recommandé, lorsque l'utilisateur est connu, d'utiliser l'Annexe B pour faciliter l'échange d'informations entre l'utilisateur et le ou les fournisseurs concernant les conditions de base et les spécifications de l'utilisateur supplémentaires relatives à l'équipement électrique. Ces spécifications complémentaires visent à:

- fournir les caractéristiques supplémentaires qui dépendent du type d'appareil de levage (ou groupe d'appareils de levage) et de l'application;
- faciliter la maintenance et la réparation; et
- améliorer la fiabilité et la facilité de fonctionnement.

NOTE L'utilisation de l'Annexe B peut également être utile pour déterminer si un appareil de levage catalogué est adapté à l'utilisation prévue.

4.2 Choix des matériels

4.2.1 Généralités

Les composants et appareils électriques doivent:

- convenir à l'usage auquel ils sont destinés; et
- être conformes aux normes correspondantes IEC lorsqu'elles existent; et
- être utilisés conformément aux instructions du fournisseur.

4.2.2 Choix des contacteurs de puissance

Les contacteurs et leurs dispositifs de protection associés contre les courts-circuits doivent être du type "2", selon l'IEC 60947-4-1:2018, 8.2.5.1.

Les contacteurs qui réalisent la fonction d'arrêt d'entraînements initiés par des circuits de commande relatifs à la sécurité doivent être choisis et combinés avec d'autres appareils, de manière que soit aucun soudage de contact ne se produise, soit la fonction d'arrêt d'urgence ne soit pas perturbée. Il convient de suivre les recommandations du fournisseur (voir aussi 7.2.9).

Il convient que les contacteurs commandant directement les mouvements aient une durée de vie mécanique et électrique qui respecte les exigences pour l'application utilisée.

4.2.3 Appareillage de connexion

En plus des exigences du présent document, selon l'appareil de levage, l'usage auquel il est destiné et son équipement électrique, le concepteur peut choisir des parties de l'équipement électrique de l'appareil de levage qui sont conformes à des parties appropriées de la série IEC 61439.

4.2.4 Choix du PDS

Pour les PDS ou une partie des PDS, lorsqu'ils sont incorporés dans l'équipement électrique des appareils de levage, l'IEC 61800-5-1 doit s'appliquer.

4.3 Alimentation électrique

4.3.1 Exigences générales

L'équipement électrique doit être prévu pour fonctionner convenablement dans les conditions d'alimentation à l'origine de l'installation (par exemple, l'interrupteur d'alimentation de la grue, voir la Figure 3):

- comme cela est spécifié en 4.3.2 ou 4.3.3; ou
- par l'utilisateur; ou
- par le fournisseur, dans le cas d'une source particulière (voir 4.3.4).

4.3.2 Alimentations en courant alternatif

Tension	Tension permanente: 0,9 à 1,1 de la tension nominale.
Fréquence	0,99 à 1,01 de la valeur nominale de façon continue; 0,98 à 1,02 sur une courte période.
Harmoniques	Distorsion harmonique inférieure ou égale à 12 % de la tension efficace totale entre conducteurs actifs (somme des harmoniques du second au trentième rang).
Déséquilibre de tension	Ni la tension de la composante inverse, ni la tension de la composante homopolaire d'alimentation triphasée ne doivent être supérieures à 2 % de la tension de la composante directe.
Coupure de tension	L'alimentation ne doit pas être interrompue ou la tension ne doit pas tomber à zéro pendant plus de 3 ms à n'importe quel instant d'une période d'alimentation. Entre deux interruptions successives, il doit s'écouler au moins 1 s.

NOTE 1 Pour des convertisseurs à semi-conducteurs de mouvement avec boucle de retour, des coupures de tension inférieures ou égales à 3 ms peuvent entraîner des conductions et la fusion de fusibles.

Creux de tension	Les creux de tension ne doivent pas dépasser 20 % de la tension efficace de l'alimentation sur plus d'une période. Entre deux creux successifs, il doit s'écouler plus de 1 s.

4.3.3 Alimentations en courant continu

Par piles ou batteries:

Tension	0,85 à 1,15 de la tension nominale; 0,7 à 1,2 de la tension nominale dans le cas de véhicules électriques.
Coupure de tension	inférieure ou égale à 5 ms.

Par convertisseur:

Tension	0,9 à 1,1 de la tension nominale.
Coupure de tension	qui ne dépasse pas 20 ms. Entre deux interruptions successives, il doit s'écouler au moins 1 s.

Ondulation (crête à crête) : qui ne dépasse pas 0,15 fois la tension nominale.

NOTE Cela diffère du Guide 106 de l'IEC, afin de garantir un fonctionnement correct de l'équipement électronique.

4.3.4 Alimentations spécifiques

Pour des alimentations spécifiques (par exemple, les générateurs embarqués, les bus à courant continu, etc.), les limites données en 4.3.2 et en 4.3.3 peuvent être dépassées si l'équipement est conçu pour fonctionner correctement dans ces conditions.

4.4 Environnement physique et conditions de fonctionnement

4.4.1 Généralités

L'appareillage électrique doit convenir à l'utilisation dans l'environnement physique et les conditions de fonctionnement de l'usage auquel il est destiné. Les exigences de 4.4.2 à 4.4.8 couvrent l'environnement physique et les conditions de fonctionnement de la plupart des appareils de levage couverts par le présent document. Lorsque des conditions particulières s'appliquent ou lorsque les limites spécifiées sont dépassées, un échange d'informations est recommandé (voir l'Annexe B) entre l'utilisateur et le fournisseur (voir 4.1).

4.4.2 Compatibilité électromagnétique (CEM)

L'équipement électrique ne doit pas engendrer de perturbations électromagnétiques de niveau supérieur à celui approprié à son environnement de fonctionnement prévu (voir l'Annexe G). De plus, l'équipement doit présenter un niveau d'immunité aux perturbations électromagnétiques, de manière qu'il puisse fonctionner en toute sécurité dans l'environnement prévu.

Pour l'équipement électrique des appareils de levage équipés de PDS ou une partie de PDS, l'IEC 61800-3:2017 doit être appliquée.

NOTE Les normes génériques de CEM telles que l'IEC 61000-6-1 ou l'IEC 61000-6-2 et l'IEC 61000-6-3 ou l'IEC 61000-6-4 ou l'IEC 61000-6-8 donnent les limites générales d'émission et d'immunité CEM.

4.4.3 Température ambiante de l'air

L'équipement électrique doit pouvoir fonctionner correctement à la température de l'air ambiant prévue. L'exigence minimale pour tous les équipements électriques est un fonctionnement correct pour une température ambiante de l'air comprise entre 0 °C et +40 °C. Pour des environnements à température très élevée (par exemple, les climats chauds, les aciéries, les papeteries) et pour des environnements froids, des mesures complémentaires sont recommandées (voir l'Annexe B).

4.4.4 Humidité

L'équipement électrique doit pouvoir fonctionner correctement en présence d'une humidité relative qui ne dépasse pas 50 % à une température maximale de +40 °C. Une humidité relative supérieure est admise pour des températures plus faibles (par exemple, 90 % à 20 °C).

Les effets gênants d'une condensation occasionnelle doivent être évités par une conception appropriée du matériel ou, si nécessaire, par des mesures complémentaires (par exemple, chauffage ou conditionnement de l'air incorporé, trous d'évacuation).

4.4.5 Altitude

Les équipements électriques doivent pouvoir fonctionner correctement jusqu'à une altitude de 1 000 m au-dessus du niveau moyen de la mer.

Pour les équipements destinés à être utilisés à des altitudes plus élevées, il est nécessaire de prendre en compte les modifications des paramètres, par exemple, la réduction de:

- la rigidité diélectrique; et
- la capacité de connexion des appareils; et
- l'effet de refroidissement de l'air.

D'autres paramètres des différents composants peuvent également varier avec l'altitude. Lorsque l'altitude peut affecter la caractéristique d'un composant, un facteur de correction approprié doit être appliqué conformément aux instructions de son fabricant.

4.4.6 Agents de pollution

L'équipement électrique doit être convenablement protégé contre les entrées de solides ou de liquides (voir 11.3).

L'équipement électrique doit être convenablement protégé contre les polluants (par exemple, les poussières, les acides, les gaz corrosifs, les sels) qui peuvent être présents dans l'environnement dans lequel il faut installer l'équipement électrique.

4.4.7 Rayonnements ionisants et non ionisants

Dans le cas où l'équipement est soumis à des rayonnements (par exemple, micro-ondes, UV, laser, rayons X), des mesures complémentaires doivent être prises pour éviter les mauvais fonctionnements et la détérioration accélérée des isolants.

4.4.8 Vibrations, chocs et coups

Les effets indésirables des vibrations, chocs et coups (aussi bien générés par l'appareil de levage et son appareillage associé que créés par l'environnement physique) doivent être évités par le choix d'un équipement approprié, par son montage loin des sources de vibration, ou par la mise en place d'accessoires de montage anti-vibratoires.

4.5 Transport et stockage

L'équipement électrique doit pouvoir, par conception ou grâce à des précautions adéquates, supporter des températures de transport et de stockage dans une plage comprise entre -25°C et $+55^{\circ}\text{C}$, qui peut atteindre $+70^{\circ}\text{C}$ durant des périodes inférieures ou égales à 24 h. Des moyens convenables doivent être prévus pour éviter tout dégât dû à l'humidité, aux vibrations et aux chocs.

NOTE L'équipement électrique susceptible d'être endommagé pour des températures basses comporte des câbles isolés au PVC.

4.6 Précautions pour la manutention

Les équipements électriques lourds et massifs qui doivent être retirés de l'appareil de levage pour le transport, ou indépendants de celui-ci, doivent être équipés de moyens convenables pour la manutention par grue ou équipement similaire (voir aussi 13.4.6).

4.7 Installation

L'équipement électrique doit être installé conformément aux instructions du fournisseur de l'équipement électrique.

NOTE L'Annexe C et l'Annexe G donnent des informations supplémentaires

5 Bornes des conducteurs d'alimentation et appareils de coupure et de sectionnement

5.1 Bornes des conducteurs d'alimentation

Lorsque cela est possible, il convient que l'équipement électrique d'un appareil de levage soit raccordé à une source d'alimentation unique. S'il est nécessaire d'utiliser une autre source d'alimentation pour certaines parties de l'équipement (par exemple, circuits électroniques, embrayages électromagnétiques), il convient que cette alimentation soit autant que possible dérivée d'appareils (tels que les transformateurs, convertisseurs, etc.) faisant partie de l'équipement électrique de l'appareil de levage. Pour de grands appareils de levage complexes, plusieurs alimentations peuvent être nécessaires (voir 5.3.5.1).

À l'exception des cas où l'appareil de levage est équipé d'une prise de courant pour le raccordement à l'alimentation (voir 5.3.2 e)), il est recommandé que les conducteurs de l'alimentation se terminent à l'interrupteur d'alimentation de grue. Si cela n'est pas possible, des bornes séparées doivent être prévues.

Si un conducteur neutre est utilisé, cela doit être clairement indiqué dans le dossier technique de l'appareil de levage, par exemple, dans le schéma d'installation et le schéma des circuits, et une borne isolée particulière, marquée N, doit être prévue pour le raccordement du conducteur neutre. La borne neutre peut être fournie en tant que partie de l'appareil de sectionnement de l'alimentation.

Il ne doit y avoir aucun raccordement entre le conducteur neutre et le circuit de protection à l'intérieur de l'équipement électrique, ni usage de conducteur combiné PEN.

Exceptions: Un raccordement peut être effectué entre la borne de neutre et la borne PE au point de raccordement de l'alimentation (voir la Figure 3) de l'appareil de levage pour les schémas TN-C, à condition qu'ils soient conformes à 12.7.2.

Les bornes pour le raccordement de l'alimentation doivent être clairement identifiées en accord avec l'IEC 60445:2021. Pour l'identification de la borne du conducteur de protection externe, voir 5.2.

5.2 Borne pour le raccordement du conducteur de protection externe

Pour chaque source d'alimentation, une borne doit être prévue dans le même compartiment que les bornes des conducteurs de ligne associés (voir 8.2.1) pour le raccordement de l'appareil de levage au conducteur de protection externe.

La borne doit être d'une taille suffisante pour permettre le raccordement d'un conducteur de protection externe en cuivre de section déterminée en fonction de la taille des conducteurs de ligne associés, conformément au Tableau 1.

Tableau 1 – Section minimale des conducteurs de protection en cuivre

Section des conducteurs de ligne S mm ²	Section minimale du conducteur de protection correspondant S_p mm ²
$S \leq 16$	S
$16 < S \leq 35$	16
$S > 35$	$S/2$

Si le conducteur de protection externe n'est pas en cuivre, la taille et le type de la borne doivent être choisis en conséquence (voir aussi 8.2.2).

Pour chaque entrée d'alimentation, la borne de raccordement au conducteur de protection externe doit être identifiée par un marquage ou étiquetée avec les lettres PE (voir l'IEC 60445:2021).

5.3 Appareils de sectionnement et de connexion

5.3.1 Généralités

Les fonctions de la coupure de l'alimentation et/ou de la connexion sont réalisées par les dispositifs suivants:

- interrupteur d'alimentation de grue (voir 5.3.5);
- sectionneur de grue (voir 5.3.6);
- interrupteur de grue (voir 5.3.7).

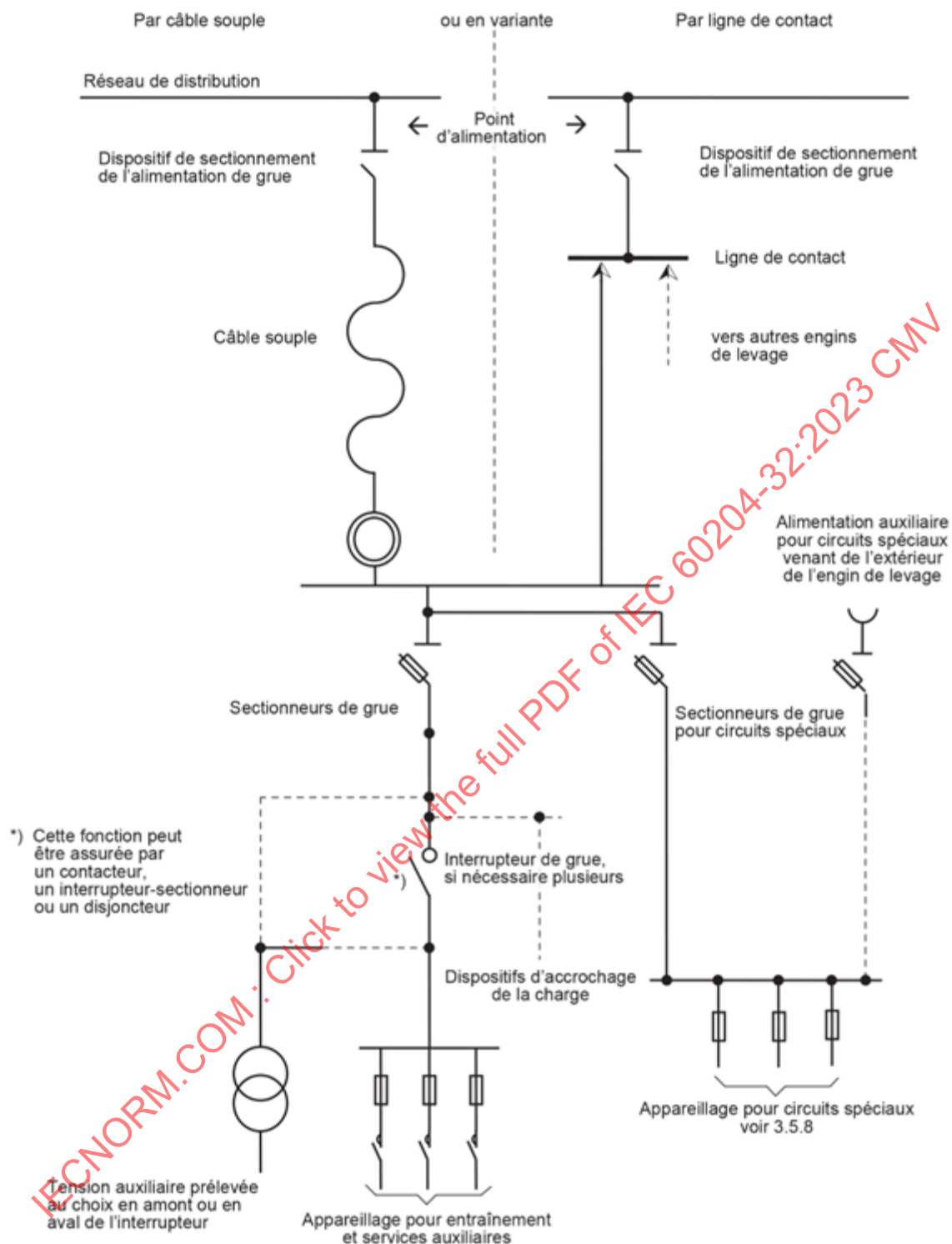
Voir également la Figure 3.

5.3.2 Type

Les appareils de sectionnement et de connexion peuvent être l'un des suivants:

- a) un interrupteur-sectionneur, avec ou sans fusible, conforme à l'IEC 60947-3, de catégorie d'emploi AC-23B ou DC-23B;
- b) un sectionneur avec ou sans fusible, conformément à l'IEC 60947-3, équipé d'un contact auxiliaire qui provoque dans tous les cas la coupure du circuit de charge par le ou les appareils de connexion avant l'ouverture des contacts principaux du sectionneur;
- c) un disjoncteur apte au sectionnement, conformément à l'IEC 60947-2:2016;
- d) tout autre appareil de connexion qui relève d'une norme de produits de l'IEC relative à cet appareil et qui satisfait aux exigences de sectionnement de l'IEC 60947-1 ainsi qu'à la catégorie d'utilisation définie dans la norme de produits appropriée et s'appliquant à la commutation des moteurs en charge ou à d'autres charges inductives;
- e) un ensemble fiche/prise pour une alimentation par câble souple;
- f) un appareil de connexion et de commande de protection adapté au sectionnement, conformément à l'IEC 60947-6-2.

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Figure 3 – Exemples de réseaux d'alimentation électrique

5.3.3 Exigences

Lorsque l'appareil de sectionnement et de connexion est l'un des types spécifiés en 5.3.2 a) à d), il doit satisfaire à toutes les exigences suivantes:

- séparer l'équipement électrique de l'alimentation, et ne posséder qu'une position MISE HORS TENSION et une position MISE SOUS TENSION, clairement repérées par "O" et "I" (symboles IEC 60417-5008 (2002-10) et IEC 60417-5007 (2002-10), voir 10.2.2);
- comporter une ouverture visible ou un indicateur de position qui ne puisse indiquer la position MISE HORS TENSION (sectionné) que si tous les contacts sont effectivement ouverts et si les exigences pour la fonction de sectionnement ont été satisfaites;
- être équipé d'un organe de manœuvre extérieur (par exemple, poignée) (exception: un appareil de connexion manœuvré par une énergie extérieure n'a pas besoin d'être manœuvré à l'extérieur de l'enveloppe s'il existe d'autres moyens pour l'ouvrir);
- pouvoir être verrouillé en position MISE HORS TENSION (sectionné) (par exemple, à l'aide de cadenas). Lorsqu'il est ainsi verrouillé, une fermeture à distance ou locale doit être empêchée;
- couper tous les conducteurs actifs de son alimentation. Cependant, dans le schéma TN, le conducteur neutre peut être sectionné ou non, excepté dans les pays dans lesquels la coupure du conducteur neutre (s'il est utilisé) est obligatoire;
- avoir un pouvoir de coupure suffisant pour interrompre le courant du moteur le plus puissant lorsqu'il est bloqué avec la somme des courants en marche normale de tous les autres moteurs et autres charges. Le pouvoir de coupure calculé peut être réduit en utilisant un facteur de diversité reconnu. Lorsque le ou les moteurs sont alimentés par un ou des convertisseurs ou des appareils similaires, il convient que le calcul tienne compte de l'effet possible sur le pouvoir de coupure exigé.

Lorsque l'appareil de sectionnement de l'alimentation est un ensemble fiche-prise, il doit satisfaire aux exigences suivantes:

- disposer de la capacité de connexion ou être interverrouillé avec un appareil de connexion dont le pouvoir de coupure est suffisant pour interrompre le courant du moteur le plus puissant lorsque son rotor est bloqué ainsi que la somme des courants en marche normale de tous les autres moteurs et autres charges. Le pouvoir de coupure calculé peut être réduit en utilisant un facteur de diversité reconnu. Lorsque l'appareil de connexion verrouillé est manœuvré électriquement (par exemple, un contacteur), il doit avoir une catégorie d'emploi appropriée. Lorsque le ou les moteurs sont alimentés par un ou des convertisseurs ou des appareils similaires, il convient que le calcul tienne compte de l'effet possible sur le pouvoir de coupure exigé;
- satisfaire aux exigences de 13.4.5.

NOTE Une fiche et un socle de prise de courant, un prolongateur ou un connecteur assignés appropriés et conformes à l'IEC 60309-1 peuvent satisfaire à ces exigences.

Si l'appareil de sectionnement de l'alimentation est un ensemble fiche-prise, un appareil de connexion d'une catégorie d'emploi appropriée doit être prévu pour mettre la machine sous tension ou hors tension. Ceci peut être réalisé par l'emploi de l'appareil de connexion verrouillé décrit ci-dessus.

5.3.4 Moyens de manœuvre de l'appareil de sectionnement de l'alimentation

Les moyens de manœuvre (par exemple, une poignée) de l'appareil de connexion et de sectionnement de l'alimentation doivent être externes à l'enveloppe de l'équipement électrique.

Exception: il n'est pas nécessaire de prévoir une poignée sur un appareil de connexion à manœuvre motorisée à l'extérieur de l'enveloppe lorsqu'il existe d'autres moyens (par exemple, boutons-poussoirs) pour ouvrir l'appareil de sectionnement de l'alimentation depuis l'extérieur de l'enveloppe.

Les moyens de manœuvre de l'appareil de connexion et de sectionnement de l'alimentation doivent être faciles à atteindre et situés entre 0,6 m et 1,9 m au-dessus du plancher de service. Une limite supérieure de 1,7 m est recommandée.

NOTE De plus amples informations concernant le sens de manœuvre sont disponibles dans l'IEC 61310-3.

Lorsque les moyens de manœuvre externes ne sont pas destinés aux manœuvres d'urgence:

- il est recommandé qu'ils soient colorés en NOIR ou GRIS (voir 10.2);
- un couvercle ou une porte supplémentaire qui peut être ouvert(e) aisément sans l'aide d'une clé ou d'un outil peut être fourni(e), par exemple, pour la protection contre les conditions d'environnement ou les dommages mécaniques. Ce couvercle/cette porte doit clairement indiquer qu'il/elle permet d'accéder aux moyens de manœuvre. Ceci peut être réalisé, par exemple, à l'aide du symbole IEC 60417-6169-1 (2012-08) (Figure 4) ou IEC 60417-6169-2 (2012-08) (Figure 5) approprié.

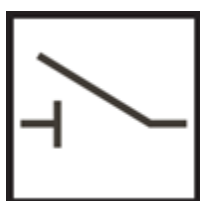


Figure 4 – Sectionneur



Figure 5 – Disjoncteur de sectionnement

5.3.5 Interrupteur d'alimentation de grue

5.3.5.1 Généralités

Les paragraphes 5.3.5.1 à 5.3.5.3 ne sont pas applicables aux appareils de levage avec alimentations embarquées et sans alimentation de remplacement issue de l'extérieur.

Des interrupteurs d'alimentation de grue doivent être prévus pour

- le sectionnement des fils conducteurs, des barres conductrices ou des câbles auxquels le ou les appareils de levage sont connectés à l'alimentation entrante pour des travaux de réparation et de maintenance (par exemple, les fils conducteurs qui alimentent l'appareil de levage); et
- lorsque cela est exigé pour l'arrêt d'urgence et/ou la coupure d'urgence (voir 9.2.5.4).

Si plus d'une alimentation est utilisée, un interrupteur d'alimentation de grue doit être prévu pour chaque alimentation avec des dispositifs d'interverrouillage pour assurer un fonctionnement correct.

Pour les interrupteurs d'alimentation de grues, les exigences de 5.6 doivent s'appliquer, si approprié.

5.3.5.2 Type

L'interrupteur d'alimentation de grue doit être de l'un des types spécifiés en 5.3.2.

Dans le cas d'appareils de levage utilisés sur des chantiers, l'équipement de l'armoire de distribution de chantier peut être utilisé pour réaliser la fonction de l'interrupteur d'alimentation de grue. Les exigences de 5.6 doivent être satisfaites par verrouillage sans considérer si le moyen de sectionnement est sous surveillance immédiate.

5.3.5.3 Exigences

Dans le cas d'un appareil de levage unique, le pouvoir de coupure doit être suffisant pour interrompre la somme du courant en condition de blocage du rotor de l'entraînement le plus important et des courants en marche normale des autres entraînements qui peuvent fonctionner au même moment.

NOTE S'il existe plus d'un appareil de levage alimenté par la même alimentation, selon les conditions de service données, un facteur approprié de simultanéité peut être utilisé.

Si l'interrupteur d'alimentation de grue réalise la fonction d'arrêt d'urgence conformément à 9.2.5.4.3, il doit pouvoir être ouvert (à distance ou directement) à partir d'un emplacement facilement accessible, proche de l'appareil de levage.

La refermeture de l'interrupteur d'alimentation de grue après une coupure d'urgence commandée à distance ne doit être possible qu'après réarmement du ou des appareils de coupure d'urgence.

Si un fil conducteur ou une barre conductrice est alimenté(e) par plusieurs sectionneurs d'alimentation de grue en parallèle sur l'alimentation, ils doivent être équipés de verrouillages de protection pour assurer leur fonctionnement correct.

Il est recommandé que l'interrupteur d'alimentation de grue ou sa cabine de commande utilisé(e) pour alimenter un fil conducteur nu ou une barre conductrice soit situé(e) de manière que le fil conducteur ou la barre conductrice soit essentiellement visible de l'emplacement de commande.

Il convient que les exigences ci-dessus s'appliquent aussi dans des cas particuliers, par exemple:

- s'il existe deux alimentations constituées de fils conducteurs, de barres conductrices ou de systèmes conducteurs, chacune pouvant alimenter les appareils de levage; ou
- si un fil conducteur ou une barre conductrice principal(e) est subdivisé(e) en sections isolées.

Dans les cas où ces exigences ne peuvent pas être remplies, la sécurité doit être assurée par d'autres moyens.

5.3.6 Sectionneur de grue

5.3.6.1 Généralités

Un appareil de levage doit être équipé d'un sectionneur de grue qui permet le sectionnement de l'installation pour des raisons d'entretien et de travaux et pour empêcher un démarrage intempestif lors des travaux sur l'appareil de levage, à l'exception des circonstances suivantes.

- Un sectionneur de grue n'est pas exigé s'il n'existe pas de connexions ni de dérivations dans la canalisation entre l'emplacement de ce sectionneur et l'interrupteur de grue spécifié en 5.3.7, si l'interrupteur réalise la fonction de sectionnement de grue et satisfait aux exigences de 5.6.

- Un sectionneur de grue n'est pas exigé pour un appareil de levage simple commandé depuis le sol et si l'interrupteur d'alimentation de grue réalise cette fonction.

NOTE Un appareil de levage commandé depuis le sol est manœuvré par un bouton de commande pendant suspendu, par un boîtier de commande fixe à distance ou un boîtier de commande portable.

- Un sectionneur de grue n'est pas nécessaire si la tension peut être mise et maintenue à zéro par d'autres moyens (par exemple, par coupure de l'alimentation de gazole d'un générateur diesel, du blocage du starter, etc.).
- Pour les appareils de levage alimentés sous des tensions alternatives supérieures à 1 kV et qui possèdent un ou plusieurs transformateurs embarqués, alimentant un réseau à basse tension, un ou plusieurs sectionneurs de grue peuvent être exigés sur les secondaires de chaque transformateur pour isoler des parties à basse tension (voir aussi 5.5). Les circuits associés à chaque sectionneur de grue doivent être clairement identifiés, par exemple par
 - séparation; ou
 - barrières; ou
 - marquage et étiquetage.

Il convient de donner la préférence au sectionnement d'un appareil de levage par un seul sectionneur de grue.

5.3.6.2 Type

Si des dispositions sont prises contre une ouverture par inadvertance ou non autorisée, le sectionneur de grue doit satisfaire au moins aux exigences des sectionneurs données dans l'IEC 60947-3. Pour les autres cas, il doit satisfaire aux exigences des interrupteurs-sectionneurs données dans l'IEC 60947-3. L'organe de commande du sectionneur de grue doit satisfaire aux exigences de 5.3.4.

Les collecteurs démontables ou les ensembles fiche/prise peuvent être utilisés comme sectionneurs de grue s'ils réalisent la même fonction.

Pour les appareils de levage avec alimentation de remplacement, un interrupteur d'alimentation à deux positions peut être utilisé comme sectionneur de grue s'il possède une position neutre et satisfait aux exigences de 5.3.6.

5.3.6.3 Exigences

Les exigences de 5.4, 5.5 et 5.6 doivent s'appliquer, si approprié.

5.3.7 Interrupteur de grue

5.3.7.1 Généralités

Chaque appareil de levage doit avoir un ou plusieurs interrupteurs de grue, manœuvrables depuis la cabine de commande pour l'arrêt d'urgence de tous les entraînements de la grue et, si nécessaire, pour la coupure de l'alimentation électrique des autres équipements.

Les dispositifs de retenue de charge qui ne peuvent pas continuer à assurer cette fonction après coupure de l'alimentation (par exemple, aimants, dispositifs pneumatiques de retenue) doivent être alimentés directement en amont de l'interrupteur de grue.

Exceptions: Si la fonction d'arrêt d'urgence est prévue par d'autres moyens, un interrupteur de grue n'est pas exigé dans les cas suivants:

- pour les appareils de levage sur lesquels seul le levage est alimenté;
- pour les appareils de levage suspendus commandés à partir du sol avec rail fixe si le déplacement sur rail est commandé à la main ou par un moteur électrique de puissance assignée inférieure ou égale à 500 W.

5.3.7.2 Type

L'interrupteur de grue doit satisfaire au moins aux exigences des interrupteurs données dans l'IEC 60947-3. Cette exigence peut être satisfaite par l'un des types spécifiés en 5.3.2 a) ou c). Des contacteurs choisis conformément à 4.2.2 et utilisés avec des appareils de sectionnement peuvent aussi être utilisés.

5.3.7.3 Exigences

Les exigences de 5.3.3 et 5.3.4 doivent s'appliquer, si approprié. L'interrupteur de grue peut fonctionner très fréquemment. Tous les composants (par exemple, circuits de charge) doivent être choisis pour permettre de prévoir la fréquence de connexion, y compris l'utilisation dans la phase de mise en service.

5.3.8 Circuits exclus

Les circuits exclus, qui doivent être opérationnels au cours des travaux de réparation et de maintenance, doivent être alimentés en amont du sectionneur de grue, tel que cela est spécifié en 5.3.6 par l'intermédiaire d'un sectionneur spécifique (voir la Figure 3) devant satisfaire aux exigences de 5.6.

Les circuits exclus peuvent inclure, entre autres, les éléments suivants:

- les circuits avec prises de courant et éclairage;
- les circuits d'ascenseurs, d'outils de réparation et de maintenance et de grues de réparation installés dans les appareils de levage;
- les circuits de chauffage, de climatisation et de ventilation;
- les circuits des équipements électriques qui satisfont aux mesures de sécurité, par exemple, dispositif anti-collision, éclairage aérien;
- les circuits d'alarmes incendie;
- les circuits de communication, de données ou les dispositifs de stockage de programmes;
- les circuits de protection contre les baisses de tension prévus uniquement pour se déclencher automatiquement lors d'une défaillance de l'alimentation;
- les circuits de commande de verrouillage.

Les circuits exclus doivent être conçus et mis en œuvre de façon que leur fonction, lors des travaux de réparation ou de maintenance de l'appareil de levage, ne dépende pas des fils conducteurs, des barres conductrices ou des assemblages glissants non protégés.

Les circuits exclus doivent être identifiables par

- une ou plusieurs étiquettes d'avertissement permanentes, placées à proximité du sectionneur de grue;
- une mention correspondante doit être incluse dans le manuel de maintenance et une ou plusieurs des mesures suivantes doivent s'appliquer;
 - les conducteurs sont identifiés par la couleur, en prenant en compte les recommandations de 13.2.4;
 - les circuits exclus sont séparés des autres circuits;
 - les circuits exclus sont identifiés par une ou plusieurs étiquettes d'avertissement permanentes.

5.4 Appareils de coupure de l'alimentation pour éviter un démarrage intempestif

Des appareils de coupure de l'alimentation pour éviter un démarrage intempestif doivent être prévus (par exemple, quand, au cours des opérations de maintenance, la mise en marche de l'appareil de levage ou d'une partie de ce dernier peut créer un phénomène dangereux). Le sectionneur de grue (voir 5.3.6) satisfait à cette fonction pour l'ensemble de l'appareil de levage. S'il est nécessaire d'intervenir sur des parties individuelles d'un appareil de levage, des appareils de coupure complémentaires doivent être prévus pour chacune des parties qui nécessite un sectionnement propre.

De tels appareils doivent être appropriés et convenir à l'usage auquel ils sont destinés, doivent être convenablement situés, et être aisément identifiables par leur fonction et leur rôle.

NOTE 1 Le présent document ne donne pas toutes les dispositions pour empêcher les démarrages intempestifs. Voir l'ISO 14118.

NOTE 2 La coupure de l'alimentation signifie la suppression du raccordement à la source d'énergie électrique, mais n'implique pas un sectionnement.

Des moyens doivent être fournis pour empêcher la fermeture par inadvertance et/ou par erreur de ces appareils, soit à partir du poste de commande, soit à partir d'autres emplacements (voir aussi 5.6).

NOTE 3 L'ISO 14118 fournit des informations complémentaires sur l'emplacement et la manœuvre des dispositifs tels que ceux utilisés pour éviter un démarrage intempestif.

Les appareils suivants qui réalisent la fonction de sectionnement peuvent être fournis pour satisfaire à ce besoin:

- les appareils décrits en 5.3.2;
- les sectionneurs, les fusibles débrochables et les liaisons démontables, uniquement s'ils sont situés dans une zone fermée de service électrique (voir 3.1.32).

Les appareils qui n'assurent pas la fonction de sectionnement (par exemple, un contacteur ouvert par un circuit de commande ou un équipement électrique de puissance (PDS) avec une fonction "Suppression sûre du couple" (STO) conforme à l'IEC 61800-5-2) peuvent uniquement être utilisés pour empêcher le démarrage intempestif dans les situations suivantes:

- les contrôles;
- les réglages;
- les travaux sur l'équipement électrique lorsque:
 - il n'y a pas de danger lié aux chocs électriques (voir l'Article 6) ou aux brûlures;
 - les moyens de coupure restent efficaces pendant les travaux;
 - si le travail est de nature mineure (par exemple, remplacement d'appareils embrochables sans perturber le câblage existant).

Il convient que le choix d'un dispositif tienne compte, par exemple, des informations tirées de l'appréciation du risque, de l'utilisation prévue, du mauvais usage prévisible du dispositif et des personnes qui les manœuvrent.

5.5 Appareils de sectionnement pour l'équipement électrique

Des appareils doivent être fournis pour le sectionnement (déconnexion) de l'équipement électrique ou de parties de l'équipement électrique afin de rendre possibles des interventions lorsqu'il est désalimenté et sectionné. De tels appareils doivent être:

- appropriés à leur usage prévu;
- correctement placés;

- aisément identifiables par la ou les parties ou le ou les circuits de l'équipement desservi. Lorsque leur fonction et leur objet ne sont pas identifiés aisément (par exemple, par leur emplacement), ces appareils doivent comporter un marquage qui indique l'étendue de l'équipement qu'ils sectionnent.

Des moyens doivent être fournis pour empêcher la fermeture par inadvertance et/ou par erreur de ces appareils, soit à partir du poste de commande, soit à partir d'autres emplacements (voir aussi 5.6).

Le sectionneur de grue (voir 5.3.6) peut, dans certains cas, remplir cette fonction. Cependant, lorsqu'il est nécessaire d'intervenir sur des parties individuelles de l'équipement électrique d'un appareil de levage, ou sur un appareil de levage parmi plusieurs alimentés par une barre conductrice commune, un câble conducteur ou un système d'alimentation par induction commun, un appareil de sectionnement doit être prévu pour chaque partie, ou pour chaque appareil de levage qui nécessite un sectionnement séparé.

En plus du sectionneur de grue, les appareils suivants qui remplissent la fonction de sectionnement peuvent être fournis pour satisfaire à ce besoin:

- les appareils décrits en 5.3.2;
- les sectionneurs, les fusibles débrochables et les liaisons démontables, uniquement s'ils sont situés dans une zone fermée de service électrique (voir 3.1.28) et si les informations appropriées sont fournies avec l'équipement électrique (voir 17.2).

NOTE Si la protection contre les chocs électriques est assurée conformément à 6.2.2 c), les fusibles débrochables ou les liaisons démontables sont destinés à être utilisés par des personnes qualifiées ou averties.

5.6 Protection contre une fermeture non autorisée, par inadvertance et/ou par erreur

Les dispositifs décrits en 5.4 et 5.5 situés à l'extérieur d'une zone fermée de service électrique doivent être équipés de moyens pour les sécuriser en position MISE HORS TENSION (état sectionné), (par exemple, par des dispositions permettant la pose d'un cadenas, ou un verrouillage par clé captive). Lorsqu'ils sont ainsi sécurisés, la reconnexion à distance aussi bien qu'en local doit être empêchée.

En cas d'appareil de sectionnement non verrouillable utilisé à l'intérieur d'une zone fermée de service électrique (par exemple, des fusibles débrochables, des liaisons démontables), d'autres moyens de protection contre la reconnexion (par exemple, des étiquettes d'avertissement conformément à 16.1) peuvent être fournis.

Cependant, lorsqu'un ensemble fiche-prise conforme à 5.3.2 e) est situé de manière à pouvoir être conservé sous la surveillance directe de l'opérateur, il n'est pas nécessaire de fournir des moyens de sécurisation à l'état sectionné.

6 Protection contre les chocs électriques

6.1 Généralités

L'équipement électrique doit assurer la protection des personnes contre les chocs électriques par

- une protection principale (voir 6.2 et 6.4);
- une protection en cas de défaut (voir 6.3 et 6.4).

Les dispositions pour cette protection données en 6.2, 6.3 et, dans le cas de la TBTP, en 6.4, constituent le choix recommandé par l'IEC 60364-4-41:2005. Si ces dispositions recommandées ne sont pas applicables, par exemple, en raison des conditions physiques ou des conditions de fonctionnement, d'autres dispositions de l'IEC 60364-4-41:2005 peuvent être utilisées.

6.2 Protection principale

6.2.1 Généralités

Pour chaque circuit ou parties de l'équipement électrique, les mesures définies soit en 6.2.2 soit en 6.2.3 et, si cela s'applique, en 6.2.4, doivent être appliquées.

Exceptions: Lorsque ces mesures ne sont pas appropriées, d'autres mesures de protection principale (par exemple, par mise hors de portée, par utilisation de barrières ou d'obstacles, par des techniques de construction ou d'installation qui empêchent l'accès) telles qu'elles sont décrites dans l'IEC 60364-4-41:2005 peuvent être appliquées (voir 6.2.5 et 6.2.6).

Si l'équipement est situé dans des emplacements ouverts à toute personne, y compris des enfants, les dispositions de 6.2.2 avec un degré minimal de protection principale contre les contacts directs de IP4X ou IPXXD (voir l'IEC 60529) ou de 6.2.3 doivent être appliquées.

6.2.2 Protection au moyen d'enveloppes

Les parties actives doivent être placées à l'intérieur d'enveloppes qui fournissent un degré de protection contre les contacts avec parties actives d'au moins IP2X ou IPXXB (voir l'IEC 60529).

Lorsque le dessus de l'enveloppe est facilement accessible, leur degré minimal de protection contre les contacts avec les parties actives doit être IP4X ou IPXXD.

L'ouverture d'une enveloppe (c'est-à-dire ouverture des portes, couvercles, plaques de fermeture et équivalent) ne doit être possible qu'à une des conditions suivantes.

- a) La nécessité d'utiliser une clé ou un outil pour l'accès. Pour les zones fermées de service électrique, voir l'IEC 60364-4-41:2005.

NOTE 1 L'utilisation d'une clé ou d'un outil est destinée à restreindre l'accès aux personnes qualifiées ou averties (voir l'Article 17).

Toutes les parties actives (y compris celles situées à l'intérieur des portes) qui sont susceptibles d'être touchées lorsque des dispositifs prévus pour que ces actions se fassent alors que l'équipement est encore sous tension sont réarmés ou ajustés, doivent avoir un degré minimal de protection contre les contacts directs de IP2X ou IPXXB. Les autres parties actives situées à l'intérieur des portes doivent être protégées contre les contacts directs avec un degré minimal de protection de IP1X ou IPXXA.

- b) Le sectionnement de toutes les parties actives situées à l'intérieur de l'enveloppe avant que l'enveloppe ne puisse être ouverte.

Ceci peut être réalisé par l'interverrouillage de la porte avec un appareil de sectionnement (par exemple, le sectionneur de grue), de telle façon que la porte ne puisse être ouverte que lorsque l'appareil de sectionnement est ouvert, et que l'appareil de sectionnement ne puisse être fermé que lorsque la porte est fermée.

Exceptions: Un dispositif ou un outil spécial, correspondant aux exigences du fournisseur, peut permettre de neutraliser le verrouillage, à condition:

- qu'il soit toujours possible d'ouvrir l'appareil de sectionnement alors que le verrouillage est neutralisé et de verrouiller l'appareil de sectionnement en position MISE HORS TENSION ou d'empêcher par un autre moyen la fermeture non autorisée de l'appareil de sectionnement;
- que le verrouillage soit automatiquement remis en service à la fermeture de la porte;
- que toutes les parties actives (y compris celles situées à l'intérieur des portes) qui sont susceptibles d'être touchées lorsque les appareils prévus pour de telles opérations alors que l'équipement est encore connecté sont réarmés ou ajustés, soient protégées contre les contacts directs avec un degré minimal de protection de IP2X ou IPXXB, et que les autres parties actives situées à l'intérieur des portes aient un degré minimal de protection contre les contacts directs de IP1X ou IPXXA;

- que les informations appropriées concernant les procédures de neutralisation du verrouillage soient fournies avec les instructions d'utilisation de l'équipement électrique (voir l'Article 17);
- Des dispositions sont fournies pour restreindre l'accès aux personnes qualifiées ou averties des parties actives derrière les portes non directement verrouillées avec des moyens de sectionnement (voir l'Article 17).

Toutes les parties qui restent actives après l'ouverture du ou des appareils de sectionnement doivent être protégées avec un degré minimal de protection contre les contacts directs IP2X ou IPXXB (voir l'IEC 60529). Les parties ainsi protégées doivent porter un signal d'avertissement conforme à 16.2.1 (voir aussi 13.2.4 pour l'identification des conducteurs par la couleur), avec les exceptions suivantes:

- les parties qui ne peuvent être actives que par une liaison aux circuits de verrouillage et identifiées par la couleur comme potentiellement actives conformément à 13.2.4;
 - les bornes d'alimentation de l'interrupteur d'alimentation de grue et du sectionneur de grue, lorsque ces derniers sont montés seuls dans une enveloppe séparée.
- c) L'ouverture sans l'utilisation d'une clé ou d'un outil et sans le sectionnement des parties actives ne doit être possible que lorsque toutes les parties actives procurent un degré de protection minimal contre les contacts directs IP2X ou IPXXB (voir l'IEC 60529). Les barrières de protection qui assurent cette protection doivent soit nécessiter l'utilisation d'un outil pour leur démontage, soit entraîner automatiquement le sectionnement de toutes les parties actives qu'elles protègent lors de leur suppression. Lorsque la protection contre les contacts est réalisée conformément à 6.2.2 c) et qu'un danger peut être provoqué par une manœuvre manuelle des appareils (par exemple, la fermeture manuelle des contacteurs ou des relais), il convient qu'une telle manœuvre soit empêchée par des barrières de protection ou des obstacles de protection qui nécessitent un outil pour leur démontage.

6.2.3 Protection par isolation des parties actives

Les parties actives protégées par isolant doivent être complètement recouvertes d'une isolation qui ne peut être enlevée que par destruction. Cette isolation doit présenter une résistance aux efforts mécaniques, chimiques, électriques et thermiques auxquels elle peut être soumise dans les conditions de fonctionnement normal.

NOTE Les peintures, vernis, laques et produits similaires utilisés seuls ne sont en général pas considérés comme pouvant assurer une protection contre les chocs électriques dans les conditions de fonctionnement normal.

6.2.4 Protection contre les tensions résiduelles

Toute charge résiduelle supérieure à 60 V des parties actives doit être déchargée jusqu'à 60 V ou moins, en moins de 5 s après la coupure de l'alimentation, sous réserve que ce taux de décharge ne perturbe pas le bon fonctionnement de l'équipement. Cette exigence ne s'applique pas aux composants de capacité 60 μ C, ou moins. Si le taux de décharge spécifié devait perturber le bon fonctionnement de l'équipement, une plaque d'avertissement durable qui attire l'attention sur le danger et qui indique le délai exigé avant d'essayer de pouvoir ouvrir l'enveloppe doit être placée dans un endroit facilement visible ou immédiatement proche de l'enveloppe contenant les capacités.

Dans le cas de fiches ou d'appareils similaires dont le retrait se traduit par l'exposition de parties conductrices (par exemple, de broches), le temps de décharge jusqu'à 60 V ne doit pas dépasser 1 s; sinon ces parties conductrices doivent comporter une protection minimale contre les contacts directs IP2X ou IPXXB. Si ni un temps de décharge de 1 s, ni un degré minimal de protection de IP2X ou IPXXB ne peut être obtenu (par exemple, dans le cas de collecteurs démontables sur les fils conducteurs, sur les barres conductrices ou sur les assemblages glissants, voir 12.7.4), des appareils de connexion supplémentaires ou un dispositif d'avertissement approprié, par exemple une note d'avertissement concernant le danger et qui indique le délai exigé, doivent être fournis (voir 16.2.3).

NOTE Généralement, les convertisseurs de fréquence et les alimentations en courant continu de bus peuvent avoir un temps de décharge supérieur à 5 s.

6.2.5 Protection par barrières

Pour la protection par barrières, les exigences de l'IEC 60364-4-41 doivent s'appliquer.

6.2.6 Protection par mise hors de portée ou protection par mise en place d'obstacles

Pour la protection par mise hors de portée ou par mise en place d'obstacles, les exigences de l'IEC 60364-4-41 doivent s'appliquer.

Pour les systèmes à fils conducteurs ou à barres conductrices dont le degré de protection est inférieur à IP2X ou IPXXB, voir 12.7.1.

6.3 Protection en cas de défaut

6.3.1 Généralités

La protection en cas de défaut est destinée à empêcher les situations dangereuses dues à un défaut d'isolement entre les parties actives et les parties conductrices accessibles.

Pour chaque circuit ou partie de l'équipement électrique, au moins une des mesures définies en 6.3.2 à 6.3.3 doit être appliquée:

- l'apparition de tension de contact (voir 6.3.2); ou
- la coupure automatique de l'alimentation avant que le délai des mesures pour empêcher le contact avec une tension de contact ne puisse devenir dangereux (voir 6.3.3).

NOTE 1 Le risque d'effets physiologiques dommageables liés à une tension de contact dépend d'un certain nombre de facteurs. Il s'agit, entre autres, de la valeur de la tension de contact, de la durée de l'exposition possible, des facteurs environnementaux et de l'état de la peau.

NOTE 2 Pour les classes de matériels et les spécifications de protection, voir l'IEC 61140.

6.3.2 Prévention contre l'apparition d'une tension de contact

6.3.2.1 Généralités

Les mesures pour empêcher l'apparition d'une tension de contact comprennent les mesures suivantes:

- l'utilisation de matériels de classe II ou d'isolation équivalente;
- la séparation électrique.

6.3.2.2 Protection par l'emploi de matériels de classe II ou par isolation équivalente

Cette mesure est destinée à empêcher l'apparition de tensions de contact sur les parties accessibles en cas de défaut de l'isolation principale.

Cette protection est obtenue par un ou plusieurs des moyens suivants:

- des matériels ou appareils électriques de classe II (double isolation, isolation renforcée ou équivalente, conformément à l'IEC 61140);
- des ensembles d'appareillages qui possèdent une isolation totale conforme à l'IEC 61439-1;
- une isolation supplémentaire ou une isolation renforcée selon l'Article 412 de l'IEC 60364-4-41:2005 et l'IEC 60364-4-41:2005/AMD1:2017.

6.3.2.3 Protection par séparation électrique

La séparation électrique d'un circuit individuel est destinée à éviter une tension de contact résultant d'un contact avec des parties conductrices accessibles qui peuvent être mises sous tension en cas de défaut de l'isolation principale des parties actives de ce circuit.

Pour ce type de protection, les exigences de l'IEC 60364-4-41 s'appliquent.

6.3.3 Protection par coupure automatique de l'alimentation

La coupure automatique de l'alimentation d'un quelconque circuit touché par un défaut d'isolement est destinée à empêcher une situation dangereuse due à une tension de contact.

Cette mesure consiste en la coupure d'un ou plusieurs conducteurs de ligne par la manœuvre automatique d'un appareil de protection en cas de défaut. Cette coupure doit se produire dans un délai suffisamment court afin de limiter la durée d'une tension de contact à une valeur comprise dans les limites spécifiées à l'Annexe A pour les schémas TN et TT.

Cette mesure nécessite une coordination entre:

- le type du système d'alimentation, l'impédance de la source d'alimentation et le schéma de mise à la terre;
- les valeurs d'impédance des différents éléments de la ligne et des chemins de courant de défaut associés à travers le circuit de protection;
- les caractéristiques des dispositifs de protection qui détectent le ou les défauts d'isolement.

NOTE 1 Les informations détaillées de vérification des conditions de protection par une coupure automatique de l'alimentation sont données en 18.2.

Cette mesure de protection comprend à la fois

- la liaison de protection des parties conductrices accessibles (voir 8.2.3);
- et l'un des points suivants:
 - a) Dans les schémas TN, les dispositifs de protection suivants peuvent être utilisés:
 - dispositifs de protection contre les surintensités;
 - dispositifs différentiels résiduels (DDR) et un ou plusieurs dispositifs associés de protection contre les surintensités.

NOTE 2 La maintenance préventive peut être améliorée par l'utilisation d'un contrôleur d'isolement à courant différentiel résiduel (RCM – *residual current monitoring device*) conforme à l'IEC 62020-1.

- b) Dans les schémas TT, soit:
 - des dispositifs différentiels résiduels et un ou plusieurs dispositifs associés de protection contre les surintensités pour initier la coupure automatique de l'alimentation sur détection d'un défaut d'isolement d'une partie active par rapport aux parties conductrices accessibles ou par rapport à la terre; ou
 - des dispositifs de protection contre les surintensités peuvent être utilisés pour la protection en cas de défaut à condition qu'une valeur raisonnablement basse de l'impédance de boucle de défaut Z_S (voir A.2.2.3) soit assurée de manière permanente et en toute fiabilité.

NOTE 3 La maintenance préventive peut être améliorée par l'utilisation d'un contrôleur d'isolement à courant différentiel résiduel (RCM – *residual current monitoring device*) conforme à l'IEC 62020-1.

- c) Dans les schémas IT, les exigences correspondantes de l'IEC 60364-4-41 doivent être satisfaites. Lors d'un défaut d'isolement, un signal acoustique et optique doit être émis de façon durable. Après indication, le signal acoustique peut alors être désactivé manuellement. Ceci peut exiger un accord entre le fournisseur et l'utilisateur concernant la disposition de contrôleurs d'isolement et/ou de systèmes de localisation des défauts d'isolement.

NOTE 4 Dans les machines importantes, la mise en place d'un système de localisation des défauts d'isolement conformément à l'IEC 61557-9:2014 peut faciliter la maintenance.

Lorsque la coupure automatique est prévue conformément à a), et que la coupure dans le délai spécifié en A.1.1 ne peut être assurée, une liaison de protection supplémentaire doit être prévue si nécessaire pour satisfaire aux exigences de A.1.3.

Lorsqu'un entraînement électrique de puissance (PDS) est fourni, une protection en cas de défaut doit être prévue pour les circuits du PDS alimentés par le convertisseur. Lorsque cette protection n'est pas prévue dans le convertisseur, les mesures de protection nécessaires doivent être conformes aux instructions du fabricant du convertisseur.

6.4 Protection par l'utilisation de la TBTP

6.4.1 Exigences générales

L'utilisation de la TBTP (Très Basse Tension de Protection) a pour but de protéger les personnes contre les chocs électriques en cas de contact indirect et de contact direct limité (voir 8.2.5).

Les circuits TBTP doivent satisfaire aux conditions suivantes.

a) La tension nominale ne doit pas dépasser:

- 25 V valeur efficace en courant alternatif ou 60 V en courant continu lisse si l'équipement est normalement utilisé dans des locaux secs et si de larges zones de parties actives ne sont pas susceptibles d'entrer en contact avec le corps humain; ou
- 6 V valeur efficace en courant alternatif ou 15 V en courant continu lisse dans tous les autres cas.

NOTE "Lisse" est défini conventionnellement pour une tension d'ondulation sinusoïdale comme une composante d'ondulation inférieure ou égale à 10 %, valeur efficace.

- b) Un côté du circuit ou un point de la source d'alimentation de ce circuit doit être relié au circuit de protection.
- c) Les parties actives des circuits TBTP doivent être électriquement séparées des autres circuits actifs. La séparation électrique ne doit pas être inférieure à celle exigée entre le circuit primaire et le circuit secondaire d'un transformateur de sécurité (Voir l'IEC 61558-1 et l'IEC 61558-2-6).
- d) Les conducteurs de chaque circuit TBTP doivent être physiquement séparés des conducteurs des autres circuits. Si cette exigence ne peut être appliquée, les dispositions d'isolement de 13.1.3 doivent s'appliquer.
- e) Les prises de courant combinées pour les circuits TBTP doivent satisfaire aux conditions suivantes:
- 1) les fiches ne doivent pas pouvoir pénétrer dans les socles des circuits de tensions différentes;
 - 2) les socles ne doivent pas admettre des fiches des circuits de tensions différentes.

6.4.2 Sources pour TBTP

La source pour TBTP doit être l'une des suivantes:

- un transformateur de sécurité conforme à l'IEC 61558-1 et à l'IEC 61558-2-6;
- une source de courant qui assure un degré de sécurité équivalent à celui d'un transformateur de sécurité (par exemple, moteur-générateur avec enroulement présentant une séparation équivalente);
- une source électrochimique (par exemple, une batterie) ou une autre source indépendante de circuits de tension plus élevée (par exemple, un groupe moteur thermique-générateur);
- une source d'alimentation électronique conforme aux normes appropriées, qui spécifie les mesures à prendre pour veiller à ce que, même en cas de défaut interne, la tension aux bornes de sortie ne puisse être supérieure aux valeurs spécifiées en 6.4.1.

7 Protection de l'équipement

7.1 Généralités

Le présent Article 7 détaille les mesures à prendre pour protéger l'équipement contre les effets

- des surintensités qui résultent d'un court-circuit;
- des courants de surcharge;
- des températures anormales;
- de la perte ou de la diminution de la tension d'alimentation;
- de la survitesse des moteurs;
- des défauts à la terre / courants résiduels;
- d'une séquence de phases erronée;
- des surtensions dues à la foudre ou dues à des manœuvres de coupure.

Si l'un de ces dysfonctionnements entraîne le fonctionnement d'un dispositif de protection et l'arrêt d'un moteur de mouvement, un redémarrage automatique doit être empêché.

NOTE Cette exigence peut être satisfaite, par exemple, au moyen

- d'un sectionneur de grue qui ne peuvent être refermé que si tous les dispositifs de commande des opérateurs sont en position ouverte;
- de dispositifs de commande d'opérateurs qui reviennent automatiquement en position ouverte.

Si seule une partie d'un appareil de levage ou seul un groupe d'appareils de levage coordonnés est concerné(e) par le fonctionnement d'un dispositif de protection, un tel fonctionnement doit initier des réponses de commande appropriées pour assurer la coordination (voir aussi 9.3.4).

7.2 Protection contre les surintensités

7.2.1 Généralités

Une protection contre les surintensités doit être prévue lorsque le courant dans un circuit quelconque peut dépasser soit la caractéristique assignée d'un composant, soit l'intensité admissible des conducteurs, la valeur la plus faible des deux étant retenue. Les caractéristiques assignées ou les réglages à utiliser sont détaillé(e)s en 7.2.10.

7.2.2 Conducteurs d'alimentation

Sauf spécification contraire (voir l'Annexe B), le fournisseur de l'équipement électrique n'est pas responsable de la fourniture du dispositif de protection contre les surintensités pour les conducteurs d'alimentation de l'équipement électrique.

Le fournisseur de l'équipement électrique doit indiquer dans les documents d'installation les données nécessaires au dimensionnement du conducteur (y compris la section maximale du conducteur d'alimentation qui peut être raccordée aux bornes de l'équipement électrique) et au choix du dispositif de protection contre les surintensités (voir 7.2.10 et 17.2).

7.2.3 Circuits de puissance

Des dispositifs de détection et de coupure des surintensités, choisis conformément à 7.2.10, doivent être insérés dans chaque conducteur actif, y compris également les circuits qui fournissent les transformateurs du circuit de commande.

Les conducteurs suivants, pour autant qu'applicable, ne doivent pas être coupés sans que tous les conducteurs actifs associés le soient également:

- le conducteur neutre des circuits de puissance en courant alternatif;
- le conducteur mis à la terre des circuits de puissance en courant continu;
- les conducteurs de puissance en courant continu reliés aux parties conductrices accessibles des machines mobiles.

Si la section du conducteur neutre est au moins égale ou équivalente à celle des conducteurs de ligne, il n'est pas nécessaire de prévoir une détection de surintensité et un appareil de sectionnement pour le conducteur neutre. Pour un conducteur neutre qui comporte une section inférieure à celle des conducteurs de ligne associés, les mesures détaillées à l'Article 524 de l'IEC 60364-5-52:2009 doivent s'appliquer.

Dans les schémas IT, il est recommandé de ne pas utiliser le conducteur neutre. Cependant, si un tel conducteur neutre est utilisé, les dispositions détaillées en 431.2.2 de l'IEC 60364-4-43:2008 doivent s'appliquer.

7.2.4 Circuits de commande

Les conducteurs des circuits de commande reliés directement à la tension d'alimentation doivent être protégés contre les surintensités, conformément à 7.2.3.

Les conducteurs des circuits de commande alimentés par l'intermédiaire d'un transformateur ou alimentés en courant continu doivent être protégés contre les surintensités (voir aussi 9.4.3.1):

- pour les circuits de commande reliés au circuit de protection, par la mise en place d'un dispositif de protection contre les surintensités sur le conducteur coupé;
- pour les circuits de commande non reliés au circuit de protection;
 - a) lorsque tous les circuits de commande de l'équipement ont le même courant admissible, en insérant un dispositif de protection contre les surintensités sur le conducteur coupé; ou
 - b) lorsque les circuits de commande de l'équipement ont un courant admissible différent, par la mise en place d'un dispositif de protection contre les surintensités sur le conducteur commuté et sur le conducteur commun de chaque circuit de commande.

Exception: Lorsque le bloc d'alimentation fournit une valeur de courant inférieure à la fois au courant admissible des conducteurs dans un circuit et au courant assigné des composants raccordés, aucun dispositif séparé de protection contre les surintensités n'est exigé.

7.2.5 Prises de courant et conducteurs associés

La protection contre les surintensités doit être fournie pour les circuits qui alimentent des prises de courant destinées principalement à fournir la puissance aux matériels de maintenance. Des dispositifs de protection contre les surintensités doivent être prévus sur les conducteurs actifs non mis à la terre de chaque circuit qui alimente de telles prises de courant. Voir également 15.1.

7.2.6 Circuits d'éclairage

Tous les conducteurs non mis à la terre des circuits qui alimentent l'éclairage doivent être protégés contre les effets des courts-circuits par des dispositifs de protection contre les surintensités indépendants de ceux protégeant les autres circuits.

7.2.7 Transformateurs

Les transformateurs doivent être protégés par un dispositif de protection contre les surintensités dont le type et le réglage sont conformes aux instructions du fabricant. Une telle protection doit (voir aussi 7.2.10)

- éviter le déclenchement intempestif dû aux courants d'appel magnétisants des transformateurs;
- éviter un échauffement des enroulements qui dépasse la valeur permise pour la classe d'isolement du transformateur lorsqu'il est soumis aux effets d'un court-circuit à ses bornes secondaires.

7.2.8 Emplacement des dispositifs de protection contre les surintensités

Les dispositifs de protection contre les surintensités doivent être situés à l'endroit auquel une réduction de la section des conducteurs ou une autre modification réduit le courant admissible dans les conducteurs, excepté lorsque toutes les conditions suivantes sont satisfaites.

- Le courant admissible dans les conducteurs est au moins égal à celui de la charge.
- La longueur du ou des conducteurs entre le lieu de réduction du courant admissible et la position du dispositif de protection contre les surintensités n'excède pas 3 m.
- Les conducteurs sont installés de façon à réduire la possibilité de court-circuit, par exemple, s'il est protégé contre les dommages mécaniques par une enveloppe ou une canalisation, ou par d'autres moyens adaptés.

7.2.9 Dispositifs de protection contre les surintensités

Le pouvoir de coupure assigné en court-circuit doit être au moins égal au courant de défaut présumé à ce point de l'installation. Si le courant de court-circuit qui apparaît dans le dispositif de protection contre les surintensités inclut des courants autres que ceux de l'alimentation (par exemple, de moteurs, de capacités de correction du facteur de puissance), ces courants doivent être pris en considération.

Un pouvoir de coupure inférieur est permis si un autre dispositif de protection (par exemple, le dispositif de protection contre les surintensités des conducteurs d'alimentation (voir 7.2.2)) qui comporte le pouvoir de coupure nécessaire est installé du côté de l'alimentation. Dans ce cas, les caractéristiques des deux dispositifs doivent être coordonnées de façon que l'énergie traversante (I^2t) des deux dispositifs en série n'excède pas celle qui peut être supportée sans dommage par le dispositif de protection contre les surintensités du côté de la charge et par les conducteurs protégés par ce dispositif (voir Annexe A de l'IEC 60947-2:2016).

NOTE L'utilisation de dispositifs de protection contre les surintensités coordonnés comme ci-dessus peut conduire au fonctionnement de ces deux dispositifs.

Si des fusibles sont utilisés en tant que dispositifs de protection contre les surintensités, un type aisément disponible dans le pays d'utilisation doit être choisi, ou des dispositions doivent être prises pour la fourniture de pièces détachées.

7.2.10 Calibrage et réglage des dispositifs de protection contre les surintensités

Le courant assigné des fusibles ou le réglage des autres dispositifs de protection contre les surintensités doit être choisi aussi faible que possible mais être adapté aux surintensités prévues (par exemple, démarrage de moteurs ou mise sous tension de transformateurs). Lors du choix de tels appareils de protection, il faut tenir compte de la protection des appareils de connexion contre les dommages dus aux surintensités.

Le courant assigné ou le réglage d'un dispositif de protection contre les surintensités pour les conducteurs est déterminé par le courant admissible dans les conducteurs à protéger, conformément à 12.4, l'Article C.3, et le temps de coupure maximal permis t , conformément à l'Article C.4, en prenant en compte les besoins de coordination avec les autres appareils électriques dans le circuit protégé.

Dans le cas d'entraînements par plusieurs moteurs, la protection contre les surintensités dans le système d'alimentation peut ne pas pouvoir protéger un seul câble de dérivation en cas de défaillance due à un court-circuit. Des mesures de protection complémentaires ou un dimensionnement des câbles de dérivation par rapport au courant de court-circuit maximal sont exigés.

7.3 Protection des moteurs contre les échauffements anormaux

7.3.1 Généralités

La protection des moteurs contre les échauffements anormaux doit être assurée pour chaque moteur d'une puissance assignée supérieure à 2 kW.

Exceptions: Pour des applications dans lesquelles une interruption automatique du fonctionnement du moteur n'est pas acceptable (par exemple, les dispositifs de retenue de charge), les moyens de détection doivent délivrer un signal d'avertissement auquel l'opérateur peut répondre.

La protection des moteurs contre les échauffements anormaux peut être réalisée par

- protection contre les surcharges (7.3.2);

NOTE 1 Les dispositifs de protection contre les surcharges détectent dans un circuit des relations entre le temps et le courant (I^2t) supérieures à celles de la charge totale assignée du circuit et initient des réponses appropriées de la commande.

- une protection contre les températures excessives (7.3.3); ou

NOTE 2 Les appareils de détection de température captent une température excessive et initient les réponses appropriées de la commande.

- une protection par limitation de courant.

La remise en marche automatique d'un moteur après le fonctionnement d'une protection contre les échauffements anormaux doit être empêchée si cela peut provoquer une situation dangereuse ou un dommage à la machine ou au travail en cours.

7.3.2 Protection contre les surcharges

Lorsque la protection contre les surcharges est utilisée, la détection de la ou des surcharges doit être prévue dans chaque conducteur actif, à l'exception du conducteur neutre. Cependant, lorsque la détection des surcharges d'un moteur n'est pas utilisée pour la protection contre les surcharges de câbles (voir aussi l'Article C.3), la détection des surcharges peut être omise dans l'un des conducteurs. Pour des moteurs monophasés ou à alimentation à courant continu, la détection sur un seul conducteur actif non relié à la terre est admise.

Si la protection contre les surcharges est réalisée par coupure, l'appareil de connexion doit couper tous les conducteurs actifs. La coupure du conducteur neutre n'est pas nécessaire pour la protection contre les surcharges.

Dans le cas de moteurs avec des caractéristiques assignées spéciales de service qui doivent fréquemment démarrer ou freiner (par exemple, les moteurs utilisés pour l'avance ou le retour rapides, le verrouillage, les branchements et les réglages progressifs), il peut être difficile de réaliser une protection contre les surcharges dont la constante de temps s'accorde avec celle de l'enroulement à protéger. Des dispositifs de protection conçus pour des moteurs à usage spécial ou une protection contre les températures excessives (voir 7.3.3) peuvent être nécessaires.

Pour des moteurs qu'il n'est pas possible de surcharger (par exemple, les moteurs couples, les commandes de mouvement qui sont soit protégées par des dispositifs mécaniques de protection contre les surcharges, soit correctement dimensionnées), il n'est pas exigé de protection contre les surcharges.

7.3.3 Protection contre les températures excessives

La fourniture de moteurs avec protection contre les températures excessives (conformément à l'IEC 60034-11) est recommandée dans les cas où le refroidissement peut être altéré. Selon le type de moteur, la protection contre un blocage du rotor ou une perte de phase n'est pas toujours assurée par une protection contre les températures excessives; il convient alors de prévoir une protection complémentaire.

Une protection contre les températures excessives est aussi recommandée dans le cas des moteurs qu'il n'est pas possible de surcharger (par exemple, les moteurs couple, les commandes de mouvement qui sont soit protégées par des dispositifs mécaniques de protection contre les surcharges, soit correctement dimensionnées), lorsque la possibilité de températures excessives existe (par exemple, en raison d'un refroidissement plus faible).

NOTE Le refroidissement peut être altéré, par exemple, dans des environnements poussiéreux et lorsque des moteurs avec des ventilateurs montés sur arbre sont entraînés à des vitesses faibles.

7.4 Protection contre les températures anormales

Les résistances de freinage ou les autres équipements qui peuvent atteindre ou entraîner des températures anormales (par exemple, en raison d'une assignation pour un fonctionnement court ou de perte de liquide de refroidissement) et donc engendrer des situations dangereuses doivent être équipé(e)s d'un dispositif de détection adapté pour provoquer une réponse appropriée de la commande.

7.5 Protection contre l'interruption ou la baisse de la tension d'alimentation et son rétablissement ultérieur

Lorsqu'une interruption d'alimentation ou une chute de tension peut entraîner une condition dangereuse, par exemple, des dommages à l'appareil de levage ou aux charges, une protection contre les baisses de tension doit être prévue (par exemple, par mise hors tension de l'appareil de levage et/ou actionnement de freins mécaniques) à un niveau prédéterminé de tension.

NOTE Selon l'appréciation du risque, une protection contre les baisses de tension peut être omise pour des appareils de levage commandés manuellement.

Si le fonctionnement de l'appareil de levage permet une interruption ou une réduction de la tension pendant une courte période, une protection temporisée contre les baisses de tension peut être prévue. Le fonctionnement du dispositif de protection contre les baisses de tension ne doit pas compromettre le fonctionnement d'une commande d'arrêt de l'appareil de levage.

Lors du rétablissement de la tension ou de la fermeture de l'interrupteur d'alimentation, le redémarrage automatique ou intempestif de l'appareil de levage doit être empêché si ce redémarrage peut entraîner une situation dangereuse.

Dans le cas d'une réduction de tension ou d'une interruption d'alimentation affectant seulement une partie de l'appareil de levage, ou du groupe d'appareils de levage fonctionnant ensemble de manière coordonnée, la protection contre les baisses de tension doit initier les commandes de contrôle appropriées pour assurer la coordination.

7.6 Protection contre la survitesse des moteurs

Une protection contre la survitesse doit être prévue lorsqu'une survitesse peut se produire et peut provoquer une situation dangereuse, en tenant compte des mesures selon 9.2.5.5 et 9.3.3. La protection contre la survitesse doit initier les réactions appropriées de la commande et interdire un redémarrage automatique.

Il convient que la protection contre la survitesse nécessite un fonctionnement tel que la limite de vitesse mécanique du moteur ou de sa charge ne puisse être dépassée.

NOTE 1 Cette protection peut consister, par exemple, en un dispositif centrifuge, un limiteur de vitesse, ou un détecteur de vitesse intégré au système d'entraînement.

NOTE 2 Des vitesses élevées inacceptables peuvent apparaître, par exemple dans des entraînements d'appareils de levage à courant continu ou avec des entraînements à vitesse variable.

7.7 Protection contre les défauts à la terre et les courants résiduels

En complément à la protection contre les surintensités pour la coupure automatique telle qu'elle est décrite en 6.3, la protection contre les défauts à la terre et les courants résiduels peut aussi être prévue pour réduire les dommages à l'équipement dus à des courants de défaut à la terre inférieurs au niveau de détection de la protection contre les surintensités.

Le réglage des dispositifs de protection doit être aussi bas que possible en cohérence avec un fonctionnement correct de l'équipement.

Lorsque des courants de défaut sont possibles avec des composants à courant continu, un DDR de type B conformément à l'IEC TR 60755:2017 peut être exigé.

7.8 Protection de l'ordre des phases

Lorsqu'un ordre erroné des phases d'une tension d'alimentation (y compris une alimentation alternative, par exemple un générateur en cas d'urgence), peut entraîner une situation dangereuse ou des dommages à l'appareil de levage, une protection de séquence de phases doit être prévue.

NOTE Les conditions d'utilisation qui peuvent mener à un ordre de phases erroné comprennent:

- un appareil de levage transféré d'une source à une autre;
- une grue mobile équipée pour le raccordement à une alimentation externe.

Un appareil de levage équipé d'une alimentation électrique pour les équipements auxiliaires (par exemple, pour les réparations avec des palans à chaîne auxiliaires) doit être équipé d'un dispositif de protection de l'ordre des phases pour assurer la rotation correcte du moteur.

7.9 Protection contre les surtensions de foudre et de manœuvre

Des dispositifs de protection contre les surtensions (SPD, *Surge Protective Device*) peuvent être prévus pour la protection contre les surtensions d'origine atmosphérique ou de manœuvre.

Si c'est le cas,

- les SPD pour la limitation des surtensions d'origine atmosphériques doivent être connectés aux bornes d'alimentation de l'interrupteur d'alimentation de grue et/ou du sectionneur de grue;
- les SPD pour la limitation des surtensions de manœuvre doivent être connectés si nécessaire pour les équipements qui exigent une telle protection.

NOTE 1 Les informations concernant le choix et l'installation corrects des SPD sont données, par exemple, dans l'IEC 60364-4-44, l'IEC 60364-5-53, l'IEC 61643-12, l'IEC 62305-1 et l'IEC 62305-4.

NOTE 2 La liaison équipotentielle de la machine, de ses équipements électriques et des éléments conducteurs étrangers avec un réseau de liaison commun du bâtiment/site peut faciliter la réduction des perturbations électromagnétiques, y compris les effets de la foudre sur les équipements.

Si l'appréciation du risque l'exige, les grues pour l'extérieur doivent être équipées d'un système de protection contre la foudre qui comprend ce qui suit.

a) Des systèmes de capture.

Une capture séparée peut ne pas être nécessaire si la structure de la grue réalise cette fonction.

b) Des systèmes de conducteurs de descente.

La structure de l'appareil de levage, -avec tous les gonds et autres jonctions mobiles dérivés par un conducteur de terre-, peut être utilisée comme un conducteur de descente.

c) Des systèmes de raccordement à la terre.

Le raccordement à la terre peut inclure des collecteurs de terre et des rails de grue.

NOTE 1 Des recommandations pour l'appréciation du risque et pour les systèmes de protection contre la foudre sont données dans la série IEC 62305.

NOTE 2 Il peut y avoir des exigences nationales relatives à la protection contre la foudre.

7.10 Courant de court-circuit assigné

Le courant de court-circuit assigné de l'équipement électrique doit être déterminé. Ceci peut être réalisé par l'application de règles de conception, par calcul ou par essai.

NOTE Le courant de court-circuit assigné peut être déterminé, par exemple, conformément à l'IEC 61439-1, l'IEC 60909-0, l'IEC TR 60909-1 ou l'IEC TR 61912-1.

8 Liaison équipotentielle

8.1 Généralités

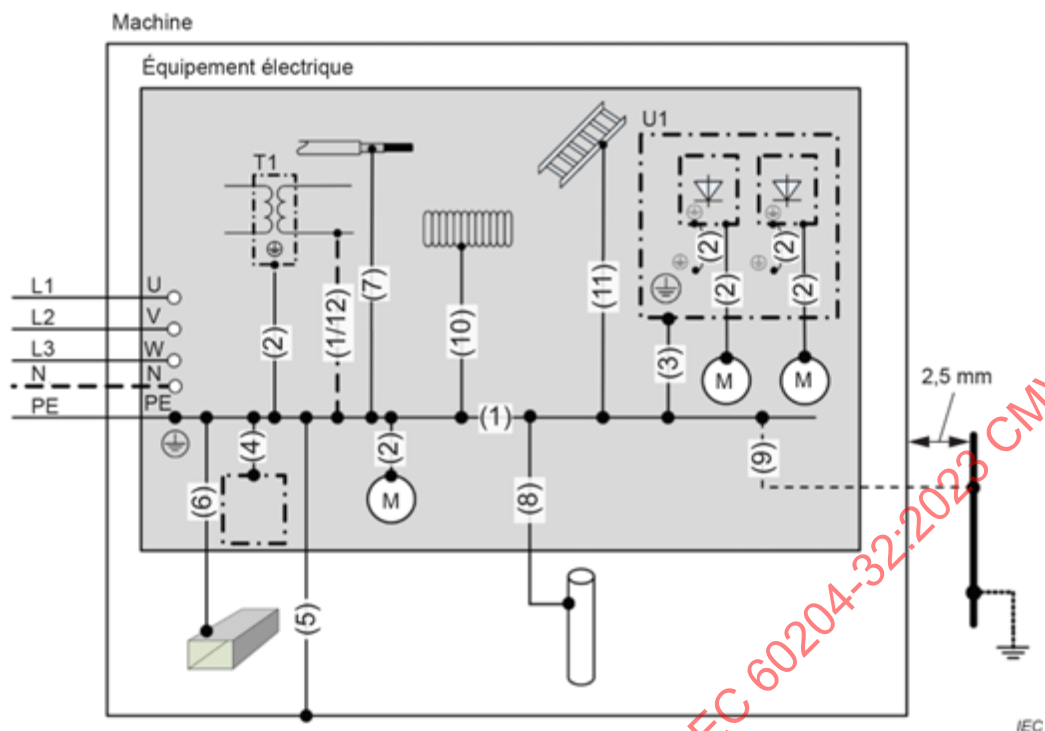
Le présent Article 8 fournit les exigences relatives aux liaisons de protection et aux liaisons fonctionnelles. La Figure 6 représente ces concepts.

La liaison de protection est une disposition de base pour la protection en cas de défaut afin d'assurer la protection des personnes contre les chocs électriques (voir 6.3.3 et 8.2).

L'objectif de la liaison fonctionnelle (voir 8.3) est de minimiser:

- les conséquences d'un défaut d'isolement qui est susceptible de nuire au fonctionnement de l'appareil de levage;
- les perturbations électriques pour les équipements électriques sensibles qui peuvent nuire au fonctionnement de l'appareil de levage;
- les courants induits en provenance de la foudre qui peuvent endommager l'équipement électrique.

La liaison fonctionnelle est assurée par le raccordement au circuit de protection mais, si le niveau des perturbations électriques sur le circuit de protection n'est pas suffisamment faible pour assurer un fonctionnement correct de l'équipement électrique, il peut être nécessaire d'utiliser des conducteurs séparés pour la liaison de protection et la liaison fonctionnelle (voir la Figure 6).



Circuit de protection:	
(1)	Interconnexion du ou des conducteurs de protection et de la borne PE
(2)	Raccordement des masses (parties conductrices accessibles)
(3)	Raccordement du conducteur de protection à une plaque d'assemblage de l'équipement électrique utilisée comme conducteur de protection
(4)	Raccordement des parties conductrices structurelles de l'équipement électrique
(5)	Parties conductrices structurelles de la machine
Parties raccordées au circuit de protection qui ne doivent pas être utilisées comme conducteur de protection:	
(6)	Canalisations métalliques souples ou rigides
(7)	Gaines ou armure de câbles métalliques
(8)	Tuyauteries métalliques contenant des matériaux inflammables
(9)	Éléments conducteurs étrangers, si mis à la terre de manière indépendante de l'alimentation de la machine et susceptibles d'introduire un potentiel, généralement le potentiel de terre, (voir 17.2 d): – tuyauteries métalliques; – clôtures; – échelles; – mains courantes.
(10)	Conduits métalliques souples ou cintrés
(11)	Liaison de protection des câbles d'appui, chemins et échelles de câbles
Raccordements au circuit de protection pour des raisons fonctionnelles:	
(12)	Liaisons fonctionnelles
Légende des désignations de référence:	
T1	Transformateur auxiliaire
U1	Plaque d'assemblage de l'équipement électrique

Figure 6 – Exemple de liaisons équipotentielles pour l'équipement électrique d'un appareil de levage

8.2 Circuit de protection

8.2.1 Généralités

Le circuit de protection comprend l'interconnexion:

- de la ou des bornes PE (voir 5.2);
- des conducteurs de protection (voir 3.1.69), y compris les contacts glissants lorsqu'ils font partie du circuit;
- des parties conductrices structurelles et des parties conductrices accessibles de l'équipement électrique;
Exception: voir 8.2.5.
- des parties conductrices structurelles de l'appareil de levage utilisées pour la liaison de protection.

Exception: Pour les grues mobiles, lorsque l'alimentation électrique est intégrée, et s'il n'existe pas de source extérieure d'alimentation (par exemple, dans le cas d'un chargeur de batteries embarqué non raccordé), il n'est pas nécessaire de raccorder un tel équipement à un conducteur de protection externe.

Toutes les parties du circuit de protection doivent être conçues pour être capables de résister aux contraintes thermiques et mécaniques les plus importantes qui peuvent être provoquées par des courants de défaut à la terre susceptibles de circuler dans ces parties du circuit de protection.

En schéma IT, la structure de l'appareil de levage doit faire partie du circuit de protection et doit être associée à une surveillance de l'isolement. Voir 6.3.3 c).

Il n'est pas nécessaire de raccorder les parties conductrices structurelles de l'équipement selon 6.3.2.2 au circuit de protection. Il n'est pas nécessaire de raccorder les éléments conducteurs étrangers qui constituent la structure de l'appareil de levage au circuit de protection, si tout l'équipement fourni est conforme à 6.3.2.2.

Les parties conductrices accessibles de l'équipement selon 6.3.2.3 ne doivent pas être raccordées au circuit de protection.

8.2.2 Conducteurs de protection

Les conducteurs de protection doivent être identifiés conformément à 13.2.2.

Les conducteurs en cuivre sont préférables. Dans le cas d'une utilisation d'un matériau conducteur autre que le cuivre, la résistance électrique par unité de longueur ne doit pas dépasser la valeur admise pour un conducteur en cuivre et sa section ne doit pas être inférieure à 16 mm² pour des raisons de durabilité mécanique.

Les enveloppes ou cadres métalliques ou les plaques d'assemblage de l'équipement électrique, raccordés au circuit de protection, peuvent être utilisés comme conducteurs de protection s'ils satisfont aux trois exigences suivantes:

- leur continuité électrique doit être assurée par construction ou par un raccordement adapté, de manière à assurer une protection contre les détériorations mécaniques, chimiques ou électrochimiques;
- ils satisfont aux exigences de 543.1 de l'IEC 60364-5-54:2011;
- ils doivent permettre le raccordement d'autres conducteurs de protection à chaque point de prélèvement prédéterminé.

La section des conducteurs de protection doit être calculée conformément à 543.1.2 de l'IEC 60364-5-54:2011, ou choisie conformément au Tableau 1 (voir 5.2). Voir également 8.2.6 et 17.2 d) du présent document.

Chaque conducteur de protection doit:

- faire partie intégrante d'un câble multiconducteur; ou
- être dans une enveloppe commune avec le conducteur de ligne; ou
- avoir une section minimale de:
 - 2,5 mm² Cu ou 16 mm² Al en cas de protection contre les dommages mécaniques;
 - 4 mm² Cu ou 16 mm² Al en l'absence de protection contre les dommages mécaniques.

NOTE 1 L'utilisation de l'acier pour un conducteur de protection n'est pas exclue.

Un conducteur de protection qui ne fait pas partie intégrante d'un câble est considéré comme protégé mécaniquement s'il est installé dans un conduit, une goulotte ou s'il fait l'objet d'une protection similaire.

Les parties suivantes de la machine et de son équipement électrique doivent être raccordées au circuit de protection, mais ne doivent pas être utilisées comme conducteurs de protection:

- les canalisations métalliques souples ou rigides;
- les gaines ou armures de câbles métalliques;
- les tuyauteries métalliques contenant des matériaux inflammables tels que des gaz, des liquides, ou des poudres;
- les conduits métalliques souples ou cintrés;
- les parties conductrices structurelles de l'appareil de levage;
- les parties métalliques souples, les câbles d'appui, les chemins et échelles de câble.

NOTE 2 Les informations concernant la protection cathodique sont données en 542.2.5 et en 542.2.6 de l'IEC 60364-5-54:2011.

8.2.3 Continuité du circuit de protection

Si un élément est retiré quelle que soit la raison (par exemple, entretien de routine), le circuit de protection pour les éléments restants ne doit pas être interrompu.

Les points de raccordement et de liaison doivent être prévus de façon que leurs intensités admissibles ne soient pas altérées par des influences mécaniques, chimiques ou électrochimiques. Lors de l'utilisation d'enveloppes et de conducteurs en aluminium ou alliage d'aluminium, il convient de porter une attention particulière à une éventuelle corrosion électrolytique.

Si l'équipement électrique est monté sur des couvercles, des portes ou des plaques de fermeture, la continuité du circuit de protection doit être assurée et un conducteur de protection est recommandé (voir 8.2.2). Sinon, des systèmes de fermeture, des charnières ou des contacts glissants conçus pour présenter une faible résistance doivent être utilisés (voir 18.2.2, Essai 1).

La continuité du conducteur de protection au sein de câbles risquant d'être endommagés (par exemple, câbles souples rampants) doit être assurée par des mesures appropriées (par exemple, surveillance).

Pour les exigences relatives à la continuité du conducteur de protection qui utilisent des câbles conducteurs, des barres conductrices et des assemblages glissants, voir 12.7.2.

Les rails d'appareils de levage peuvent être connectés au circuit de protection. Toutefois, ils ne doivent pas remplacer le conducteur de protection (par exemple, câble, fil conducteur ou barre conductrice) entre l'alimentation et l'appareil de levage.

L'équipement électrique des appareils de levage destinés à être utilisés sur différents sites (appareils de levage transportables) doit satisfaire aux exigences du présent document pour tous les schémas attendus de mise à la terre de l'alimentation. S'il est utilisé en schéma IT ou TT, le circuit de protection d'un appareil de levage doit être connecté à la prise de terre du site.

8.2.4 Exclusion des appareils de connexion du circuit de protection

Le circuit de protection ne doit comprendre ni appareil de connexion, ni dispositif de protection contre les surintensités (par exemple, interrupteur, fusible), ou tout autre moyen d'interruption.

Exceptions:

- les liaisons à des fins d'essais ou de mesurages qui ne peuvent pas être ouvertes sans l'usage d'un outil et situées dans une zone fermée de service électrique;
- lorsque la continuité du circuit de protection peut être interrompue par des collecteurs mobiles de courant ou des ensembles fiche-prise, le circuit de protection doit être interrompu par un contact premier fermé dernier ouvert. Cela concerne aussi les éléments démontables ou débrochables (voir aussi 13.4.5).

8.2.5 Parties dont le raccordement au circuit de protection n'est pas nécessaire

Il n'est pas nécessaire de raccorder au circuit de protection certaines parties conductrices accessibles si, par leur montage, elles ne présentent pas de danger du fait

- qu'elles ne peuvent pas être touchées sur de larges surfaces ou saisies par la main et qu'elles sont de faibles dimensions (moins de 50 mm × 50 mm environ); ou
- qu'elles sont placées de telle façon qu'un contact avec des parties actives ou une défaillance de l'isolation est improbable.

Ceci s'applique aux petites parties telles que vis, rivets, plaques signalétiques et aux parties situées à l'intérieur d'une enveloppe, quelles que soient leurs dimensions (par exemple, les électroaimants de contacteurs ou de relais, et les parties mécaniques des appareils).

NOTE De plus amples informations sont données en 410.3.9 de l'IEC 60364-4-41:2005.

8.2.6 Points de raccordement du conducteur de protection

Tous les conducteurs de protection doivent être raccordés conformément à 13.1.1. Les points de raccordement du conducteur de protection ne doivent pas présenter d'autres fonctions et ne doivent pas, par exemple, être utilisés pour la fixation ou le raccordement d'appareils ou d'éléments.

Chaque point de raccordement du conducteur de protection doit être marqué ou étiqueté comme tel par le symbole IEC 60417-5019 (2006-08), comme cela est représenté à la Figure 7, ou par les lettres PE, le symbole graphique étant préférentiel, ou par la combinaison bicolore VERT-ET-JAUNE, ou par toute combinaison des moyens précités.



Figure 7 – Symbole IEC 60417-5019: Terre de protection