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- 機械安全国際規格の紹介 -

機械の電気装置の安全(IEC 60204-1)

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IEC60204-1について

IEC 60204-1:2016

Safety of machinery -Electrical equipment of machines -
Part 1: General requirements

JIS B 9960-1:

機械類の安全性　ー機械の電気装置ー
第1部:一般要求事項　（現在JIS化推進中）

機械における電気設備での感電・電気火災等に対する
安全性要求事項を規定する国際規格

改訂履歴

1997年10月　第4版発行
2005年10月　第5版発行
2016年10月　第6版発行

Introduction

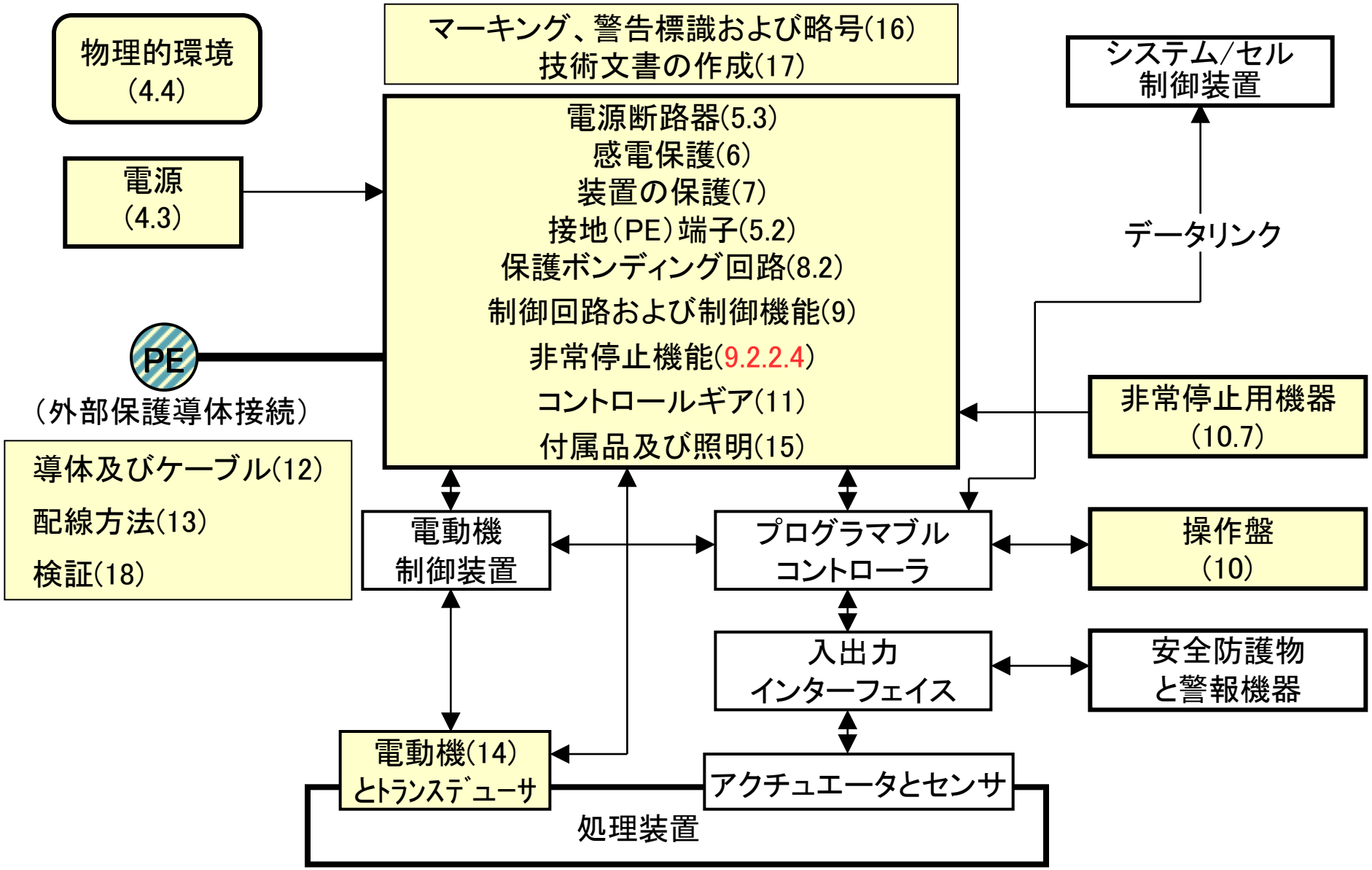
- 人と財産の安全確保
  （safety of persons and property）

- 制御応答の一貫性（正しい制御・応答）の確保
  （consistency of control response）

- 操作と保全の容易性の確保
  （ease of operation and maintenance）

IEC60204-1

Figure 1 Block diagram of a typical machine



3.1. Terms and definitions
新たな用語(1)

3.1.4 basic protection

protection against electric shock under fault-free conditions

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

3.1.8 conductor wire conductor bar

conductive wire or bar of a feeder system with a sliding current collector

3.1.12 control station operator control station

assembly of one or more control actuators (see 3.1.1) 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

3.1.18 earth local earth / ground (US) **local ground** (US)

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

3.1.25 electrical equipment

items used in connection with the utilization of electricity by machines or parts of machines, for example material, fittings, devices, components, appliances, fixtures, apparatus, and the like used as part of, or in connection with, the electrical equipment of machines similar

3.1. Terms and definitions
新たな用語(2)

3.1.31 fault protection

protection against electric shock under single-fault conditions

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

3.1.37 interlock (for safeguarding)

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

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

3.1.48 prospective short-circuit current *I*cp

r.m.s. value of the current which would flow when the supply conductors to the electrical equipment are short-circuited by a conductor of negligible impedance located as near as practicable to the supply terminals of the electrical equipment

3.1. Terms and definitions
新たな用語(3)

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

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

3.1.60 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

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

3.2．Abbreviated terms
略号

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
IFLS	Insulation Fault Location System
MMI	Man-Machine interface
PDS	Power Drive System
PELV	Protective Extra-Low Voltage
RCD	Residual Current protective Device
SPD	Surge Protective Devices
SCPD	Short-Circuit Protective Device
SELV	Safe Extra-Low Voltage
SLP	Safely-Limited Position
STO	Safe Torque Off

4 General requirements

4.4.2 Electromagnetic compatibility (EMC)

- 本文の簡略化

- EMC対策はAnnex Hに例示された

- NOTE 1に 一般的なEMC関連規格が示されている。

IEC 61000-6-1：電磁両立性(EMC)－第6-1部：一般規格－
住宅，商業及び軽工業環境のイミュニティ規格

IEC 61000-6-2：電磁両立性(EMC)－第6-2部：一般規格－
工業環境のイミュニティ規格

IEC 61000-6-3：電磁両立性(EMC)－第6-3部：一般規格－
住宅，商業及び軽工業環境のエミッション規格

IEC 61000-6-4：電磁両立性(EMC)－第6-4部：一般規格－
工業環境のエミッション規格

Annex H(informative)

Annex H (informative)

Measures to reduce the effects of electromagnetic influences

H.1 Definitions

For the purposes of Annex H only, the following terms and definitions apply.

H.1.1 apparatus

H.1.2 fixed installation

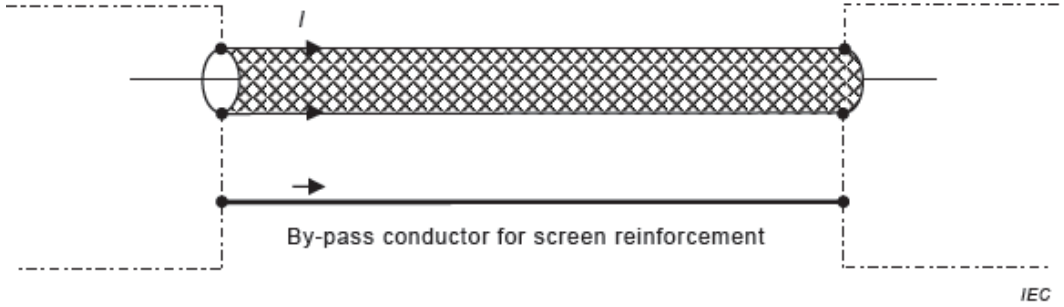
H.2 General

This Annex H provides recommendations to improve electromagnetic immunity and reduce emission of electromagnetic disturbances

H.3 Mitigation of electromagnetic interference (EMI)

H.3.1 General

H.3.2 Measures to reduce EMI



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

5.3.4 Operating means of the supply disconnecting device

The operating means (for example, a handle) of the supply disconnecting 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.

～中略～

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 2) or IEC 60417-6169-2 (2012-08), (Figure 3).

Figure 2 – Disconnector isolator

Figure 3 – Disconnecting circuit breaker

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

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

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 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 (for example, replacement of plug-in devices without disturbing existing wiring).

6 Protection against electric shock

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

–**basic protection** (see 6.2 and 6.4), and;

–**fault protection** (see 6.3 and 6.4).

6.2 Basic protection

In the case of plugs or similar devices, the withdrawal of which results in the exposure of conductors (for example pins), the discharge time to 60 V shall not exceed 1 s, otherwise such conductors shall be protected to at least IP2X or IPXXB. If neither a discharge time of 1 s nor a protection of at least IP2X or IPXXB can be achieved (for example in the case of removable collectors on conductor wires, conductor bars, or slip-ring assemblies, see 12.7.4), additional switching devices or an appropriate warning, for example a warning sign drawing attention to the hazard and stating the delay required shall be provided. When the equipment is located in places open to all persons, which can **include children, warnings are not sufficient** and **therefore a minimum degree of protection against contact with live parts to IP4X or IPXXD is required**.

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

6 Protection against electric shock

6.3 Fault protection

6.3.3 Protection by automatic disconnection of supply

This protective measure comprises both:

– protective bonding of exposed conductive parts (see 8.2.3),

– and one of the 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.

6 Protection against electric shock

6.3 Fault protection

6.3.3 Protection by automatic disconnection of supply

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.

6 Protection against electric shock

6.3 Fault protection

6.3.3 Protection by automatic disconnection of supply

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 (IFLS) in accordance with IEC 61557-9 can facilitate maintenance.

6 Protection against electric shock

6.3 Fault protection

6.3.3 Protection by automatic disconnection of supply

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 power drive system 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**.

7 Protection of equipment

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 circuits supplying control circuit transformers.**

7.2.4 Control circuits

– in control circuits not connected to the protective bonding circuit;

- where ~~the same cross sectional area conductors are used in all control circuits~~ **all control circuits of the equipment have the same current carrying capacity**, by inserting an overcurrent protective device into the switched conductor, ~~and~~ **or**;
- where different ~~cross sectional areas conductors are used in different sub-circuits~~ **control circuits of the equipment have different current carrying capacity**, by inserting an overcurrent protective device into both switched and common conductors of each ~~sub-~~ 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 Protection of equipment

~~7. 4 Current limiting protection~~ **削除**

7.10 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 may be determined, for example, in accordance with IEC 61439-1, IEC 60909-0, IEC/TR 60909-1, or IEC/TR 61912-1.

IEC 61439-1:低電圧開閉装置及び制御装置アセンブリー第1部:一般規則

IEC 60909-0:三相交流システムの短絡電流ー第0部:電流の計算

IEC/TR 60909-1:三相交流システムの短絡電流ー第1部:IEC 60909による短絡電流計算のための係数

IEC/TR 61912-1:低電圧開閉装置及び制御装置ー過電流保護装置ー第1部:短絡定格の適用

8 Equipotential bonding

8.1 General

The objective of functional bonding (see 8.4) is to minimize reduce:

– the consequence of an insulation failure which could affect the operation of the machine;

~~– the consequences of electrical disturbances to sensitive electrical equipment which could affect the operation of the machine.~~

– electrical disturbances to sensitive electrical equipment which could affect the operation of the machine;

– induced currents from lightning which could damage the electric equipment.

8 Equipotential bonding

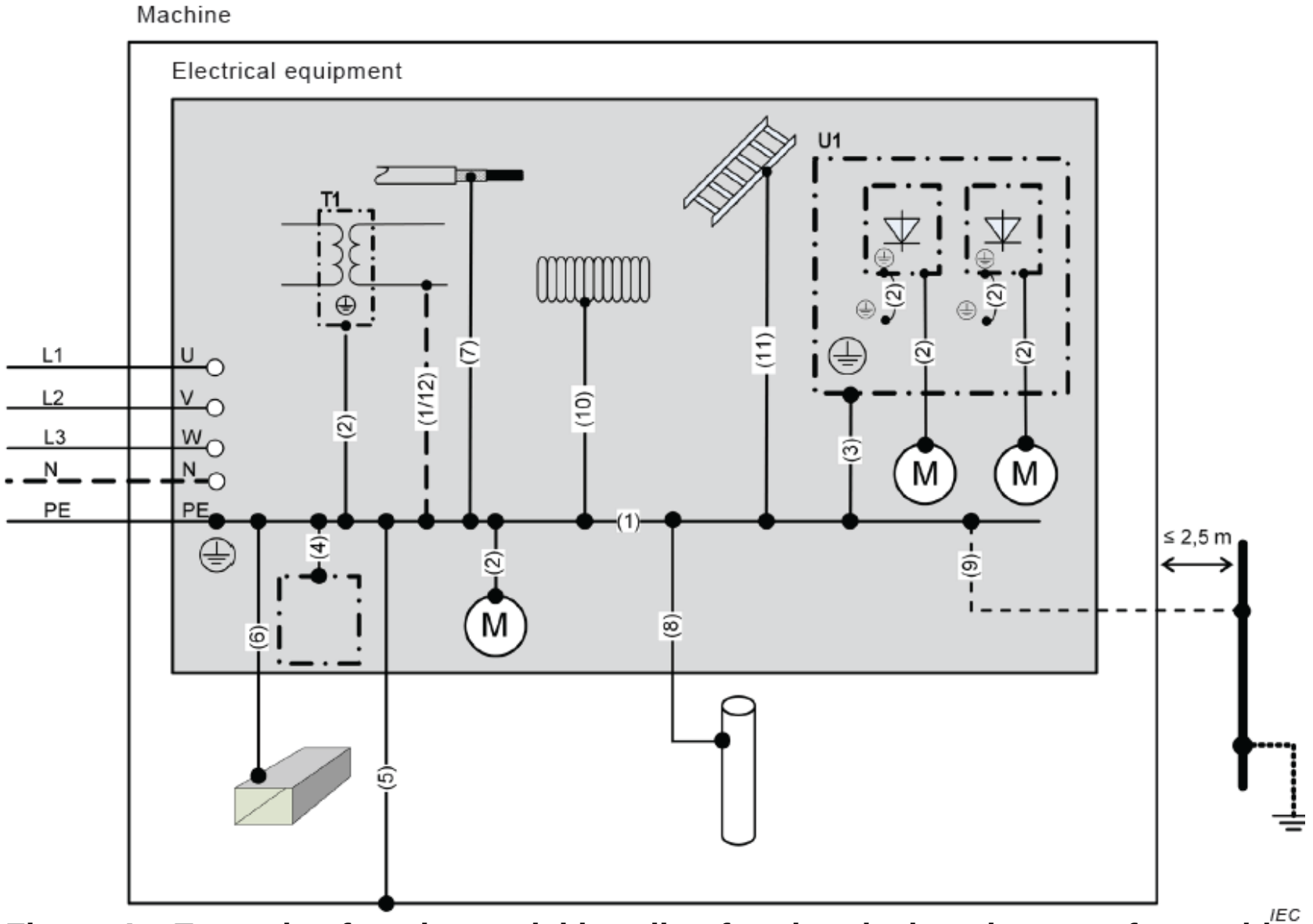


Figure 4 – Example of equipotential bonding for electrical equipment of a machine

8 Equipotential bonding

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, cables tray 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 4 – Example of equipotential bonding for electrical equipment of a machine

8 Equipotential bonding

8.2 Protective bonding circuit

8.2.1 General

The cross-sectional area of every protective conductor which does not form part of a cable or which is not in a common enclosure with the line conductor shall be **not less than**

- **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 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. Conductive structural parts of equipment in accordance with 6.3.2.2 need not be connected to the protective bonding circuit. Conductive structural parts of the machine need not be connected to the protective bonding circuit where all the equipment provided is in accordance with 6.3.2.2.

8 Equipotential bonding

8.2 Protective bonding circuit

8.2.2 Protective conductors

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 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.

8 Equipotential bonding

8.2 Protective bonding circuit

8.2.2 Protective conductors

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 mm^2 Cu or 16 mm^2 Al if protection against mechanical damage is provided;
- 4 mm^2 Cu or 16 mm^2 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.

8 Equipotential bonding

8.4 Functional bonding

Functional bonding connecting points should be marked or labelled as such using the symbol IEC 60417-5020:2002-10 (see Figure 6).

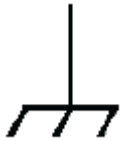


Figure 6 – Symbol IEC 60417-5020: Frame or chassis

9 Control circuits and control functions

9.1 Control circuits

9.1.1 Control circuit supply

Where control circuits are supplied from an AC source, transformers having separate windings shall be used to separate the power supply from the control supply.

Examples include:

- control 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.

9 Control circuits and control functions

9.1 Control circuits

9.1.2 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 Control circuits and control functions

9.2 Control functions

9.2.1 General

9.2.2 Categories of stop functions

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 declutching, disconnecting, switching off, or by electronic means** (e.g. a PDS in accordance with IEC 61800 series), etc.

9.2.3 Operation

9.2.3.2 Start

Start functions shall operate by energizing the relevant circuit.

The provision of acoustic and/or visual warning signals before the starting of hazardous machine operation should be considered.

9 Control circuits and control functions

9.2 Control functions

9.2.3.5 Operating modes

Each machine can have one or more operating modes **(for example manual mode, automatic mode, setting mode, maintenance mode)** determined by the type of 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**). 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**).

9 Control circuits and control functions

9.2 Control functions

9.2.4 Cableless control system (CCS)

9.2.4.1 General requirements

Subclause 9.2.4 deals with the functional requirements of control systems employing cableless (for example radio, infra-red) techniques for transmitting control signals and data **between operator control station(s) and other parts of the control system(s).**

NOTE 1 Reference to a machine in 9.2.4 is intended to be read as “machine or part(s) of a machine”.

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).

The CCS shall have functionality and a response time suitable for the application based on the risk assessment.

NOTE 2 IEC 61784-3 describes communication failures of communication networks and requirements for safetyrelated data transmission.

NOTE 3 Further requirements for cableless control systems are under development by IEC TC 44 in draft IEC 62745.

9 Control circuits and control functions

9.2 Control functions

9.2.4 Cableless control system (CCS)

9.2.4.2 Monitoring the ability of a cableless control system to control a machine

The ability of a cableless control system (CCS) to control a machine shall be **automatically monitored**, either continuously or at suitable intervals. **The status of this ability shall be clearly indicated** (for example, by an indicating light, a visual display indication, etc.)

If the communication signal is degraded in a manner that might lead to the loss of the ability of a CCS to control a machine (e.g., reduced signal level, low battery power) **a warning to the operator shall be provided before the ability of the CCS to control a machine is lost.**

When the ability of a CCS to control a machine has been lost for a time that is **determined from a risk assessment of the application**, an **automatic stop of the machine** shall be initiated.

9 Control circuits and control functions

9.2 Control functions

9.2.4 Cableless control system (CCS)

9.2.4.2 Monitoring the ability of a cableless control system to control a machine

NOTE In some cases, for example, in order to avoid this automatic stop generating an unexpected hazardous condition, it can be necessary for the machine to go to a predetermined state before stopping.

Restoration of the ability of a CCS to control a machine shall not restart the machine**. Restart shall require a deliberate action, for example manual actuation of a start button**.

9.2.4.3 Control limitation

Cableless operator control station(s) shall **only control the intended machine(s)** and shall **affect only the intended machine functions**.

9 Control circuits and control functions

9.2 Control functions

9.2.4 Cableless control system (CCS)

9.2.4.4 Use of multiple cableless operator control stations

When more than one cableless operator control station is used to control a machine, then:

- **only one cableless operator control station shall be enabled** at a time except as necessary for the operation of the machine;
- **transfer of control from one cableless operator control station to another** shall require a deliberate manual action at the control station that has control;
- during machine operation, transfer of control shall only be possible when **both cableless operator control stations are set to the same mode of machine operation and/or function(s) of the machine;**
- transfer of control **shall not change the selected mode of machine operation** and/or function(s) of the machine;
- **each cableless operator control station** that has control of the machine shall be provided **with an indication that it has control** (by for example, the provision of an indicating light, a visual display indication).

NOTE Indications at other locations can be necessary as determined by the risk assessment.

9 Control circuits and control functions

9.2 Control functions

9.2.4 Cableless control system (CCS)

9.2.4.5 Portable cableless operator control stations

Portable cableless operator control stations shall be provided with means **(for example key operated switch, access code)** **to prevent unauthorized use**. Each machine under cableless control **should have an indication when it is under cableless control.**

When a portable cableless operator control station can be connected to one or more of several machines, means shall be provided on the portable cableless operator control station to **select which machine(s) is to be connected**. **Selecting a machine to be connected shall not initiate control commands**.

9.2.4.6 Deliberate disabling of cableless operator control stations

Where a cableless operator control station is disabled when under control, the associated machine shall meet the requirements **for loss of ability of a CCS to control a machine in 9.2.4.2.**

Where it is necessary to disable a cableless operator control station **without interrupting machine operation**, means shall be provided (for example on the cableless operator control station) to **transfer control to another fixed or portable control station.**

9 Control circuits and control functions

9.2 Control functions

9.2.4 Cableless control system (CCS)

9.2.4.7 Emergency stop devices on portable cableless operator control stations

Emergency stop devices on portable cableless operator control stations **shall not be the sole means of initiating the emergency stop function of a machine**. **Confusion between active and inactive emergency stop devices** shall be avoided by appropriate design and information for use. **See also ISO 13850**.

9.2.4.8 Emergency stop reset

Restarting of cableless control after power loss, disabling and re-enabling, loss of communication, or failure of parts of the CCS shall not result in a reset of an emergency stop condition.

The instructions for use shall state that the reset of an emergency stop condition initiated by a **portable cableless operator control station shall only be performed** when it can be seen that the reason for initiation has been cleared.

Depending on the risk assessment, in addition to the resetting of the emergency stop actuator on the portable cableless operator control station, **one or more supplementary fixed reset devices should be provided**.

9.3 Protective interlocks

9.3.6 Suspension of safety functions and/or protective measures

Where it is necessary to suspend safety functions and/or protective measures (for example for setting or maintenance purposes), the control or operating mode selector shall simultaneously:

- disable all other operating (control) modes;
- permit operation **only by the use of a hold-to-run device** or by a similar control device positioned so as to permit sight of the hazardous elements;
- permit operation of the hazardous elements only in **reduced risk conditions** (**e.g. reduced speed, reduced power / force, step-by-step operation, e.g. with a limited movement control device**);
- prevent any operation of hazardous functions by **voluntary or involuntary action on the machine's sensors**.

If these four conditions cannot be fulfilled simultaneously, **the control or operating mode selector shall activate other protective measures designed** and constructed to ensure a safe intervention zone. In addition, the operator shall be able to control operation of the parts he is working on from the adjustment point.

9 Control circuits and control functions

9.4 Control functions in the event of failure

9.4.1 General requirements

Where functions performed by the electrical control system(s) have safety implications but application of IEC 62061 leads to a required safety integrity **less than that required by SIL 1**, **compliance with the requirements of this part of IEC 60204 can lead to an adequate performance of the electrical control system(s).**

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 Control circuits and control functions

9.4 Control functions in the event of failure

9.4.3 Protection against malfunction of control circuits

9.4.3.1 Insulation faults

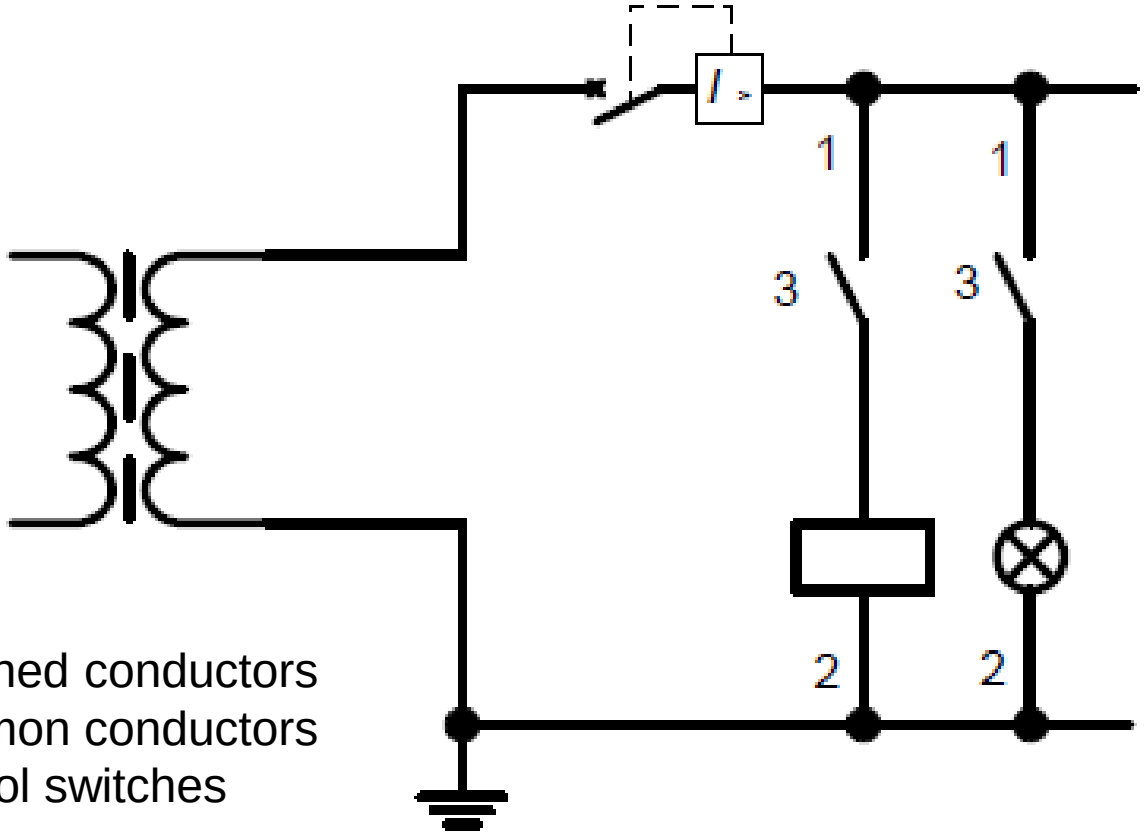
9.4.3.1.1 General

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)

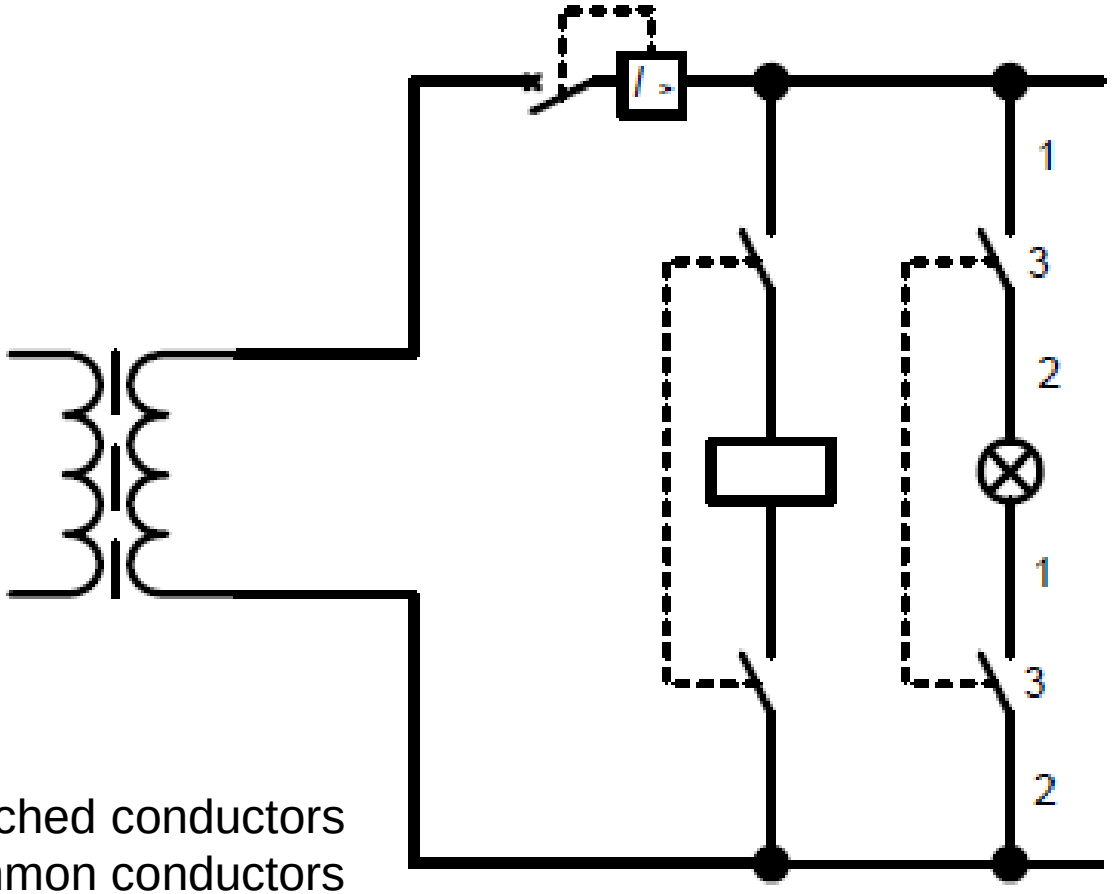


1 Switched conductors
2 Common conductors
3 Control switches

Figure 7 – 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 7 is substituted by a **DC power supply unit**

9.4.3.1.3 Method b1)

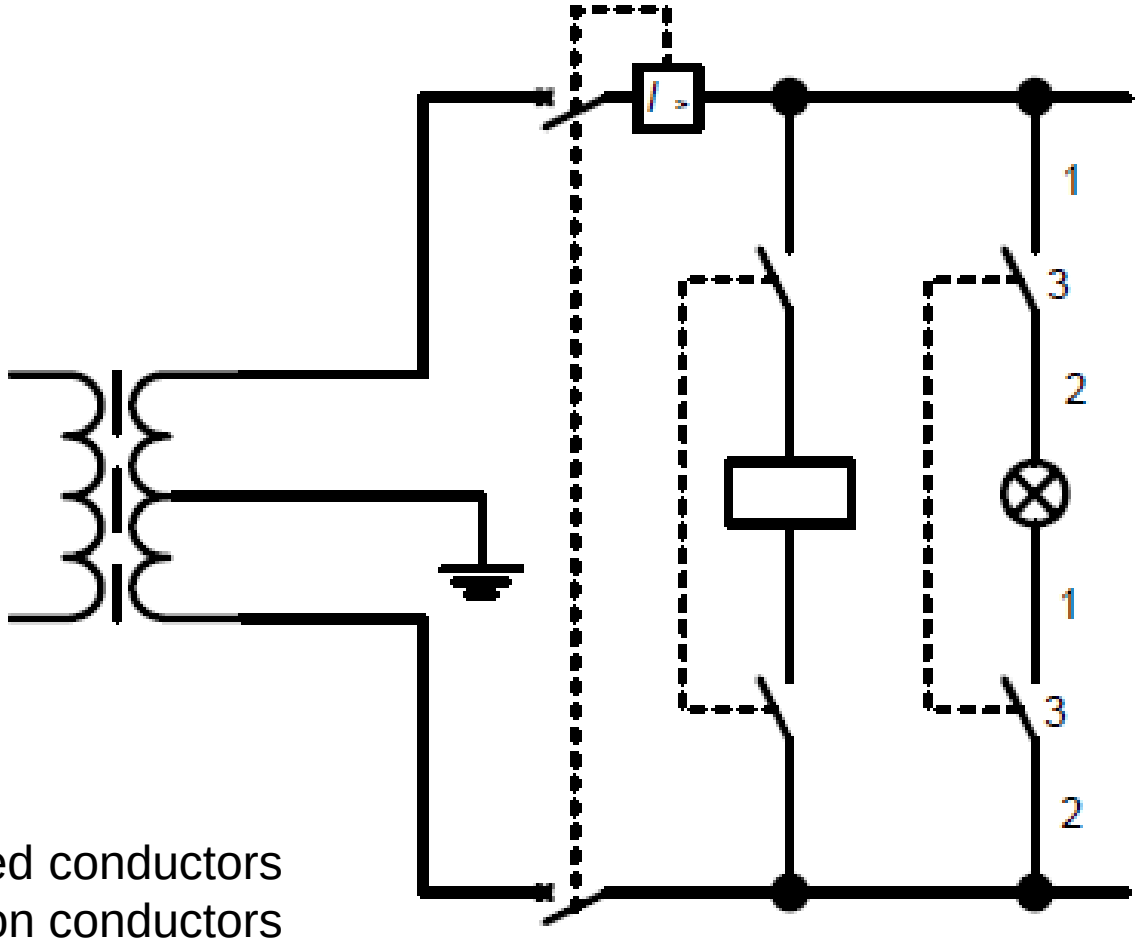


1 Switched conductors
2 Common conductors
3 Control switches

Figure 8 – 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 8 is substituted **by a DC power supply**.

9.4.3.1.4 Method c)



1 Switched conductors
2 Common conductors
3 Control switches

Figure 11 – Method c) Control circuits fed by transformer with an earthed centre-tap winding

9.4.3.1.5 Method d1a)

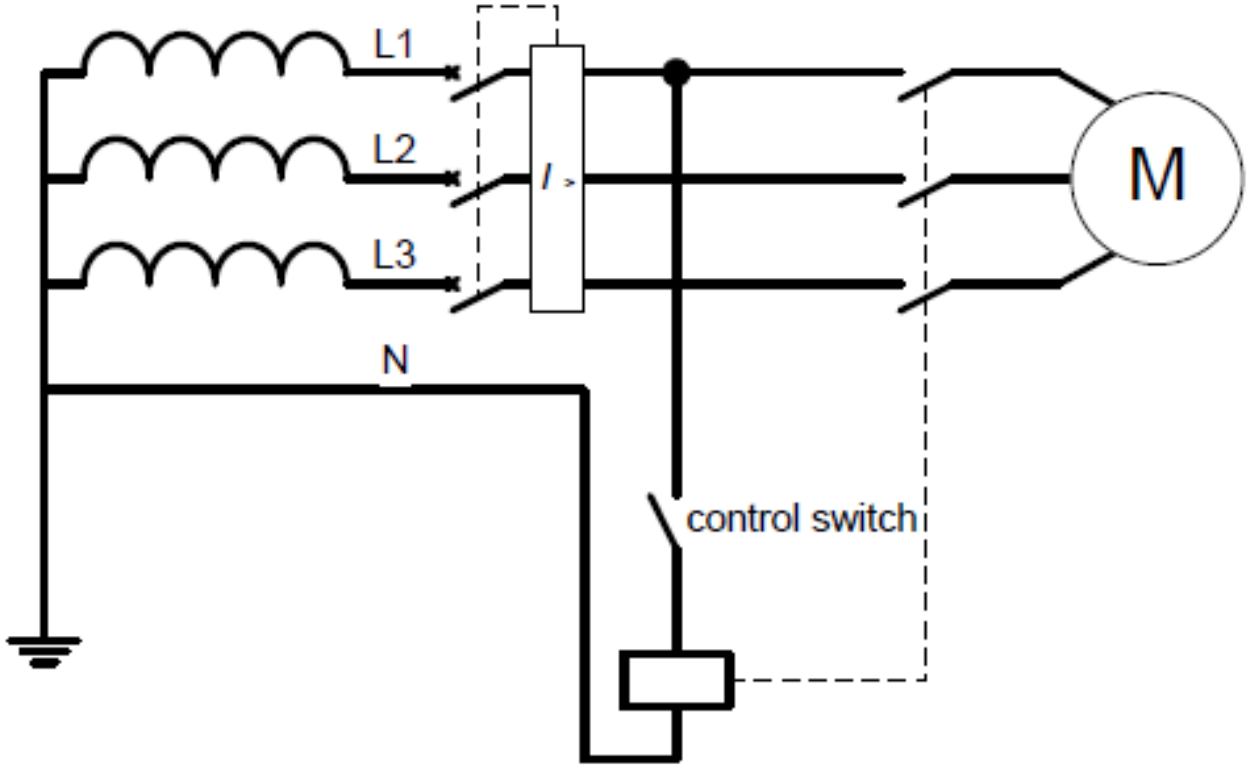


Figure 12 – Method d1a) Control circuit without transformer connected between a phase and the neutral of an earthed supply system

NOTE 1 Figure 12 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 12 does not show any protective devices for the power circuit and control circuit, provisions for which are stated in 6.3 and 7.2.

10 Operator interface and machine-mounted control devices

10.1 General

10.1.1 General requirements

Ergonomic principles shall be taken into account in the location of operator interface devices.

10.2 Actuators

Actuators (see 3.1.1) shall be 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.

10 Operator interface and machine-mounted control devices

10.2 Actuators

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 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.

10 Operator interface and machine-mounted control devices

10.2 Actuators

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 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 or 3.

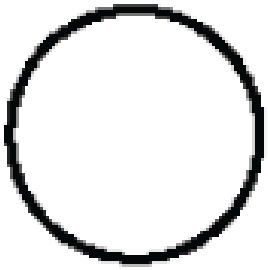
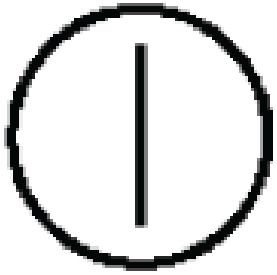
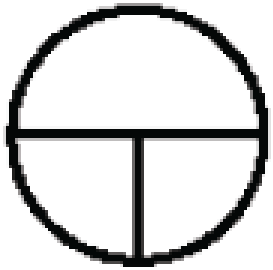
Power			
ON	OFF	ON/OFF (push on-push off)	ON (hold-to-run)
IEC 60417-5007 (2002-10)	IEC 60417-5008 (2002-10)	IEC 60417-5010 (2002-10)	IEC 60417-5011 (2002-10)
			

Table 2 – Symbols for actuators (Power)

10 Operator interface and machine-mounted control devices

10.2 Actuators

10.2.2 Markings

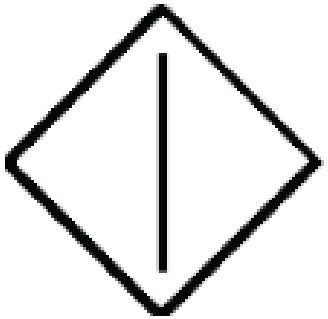
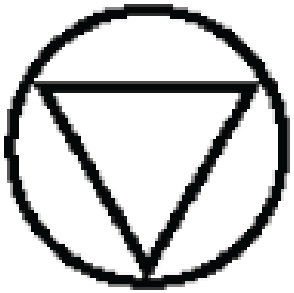
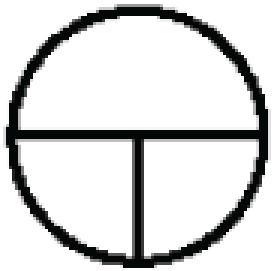
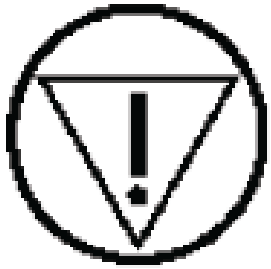
Machine operation			
START	STOP	HOLD-TO-RUN	EMERGENCY STOP
IEC 60417-5104 (2006-08)	IEC 60417-5110A (2004-06)	IEC 60417-5011 (2002-10)	IEC 60417-5638 (2002-10)
			

Table 3 – Symbols for actuators (Machine operation)

11 Controlgear: location, mounting, and enclosures

11.5 Access to electrical equipment

Doors in gangways and for access to electrical operating areas shall:

– be at least 0,7 m wide and 2,0 m high;
– open outwards;
– have a means (for example panic bolts) to allow opening from the inside without the use of a key or tool.

NOTE Further information is given in IEC 60364-7-729.

要求の簡略化

12 Conductors and cables

Table 6 – Examples of current-carrying capacity (*Iz*) of PVC insulated copper conductors or cables under steady-state conditions in an ambient air temperature of +40 °C for different methods of installation

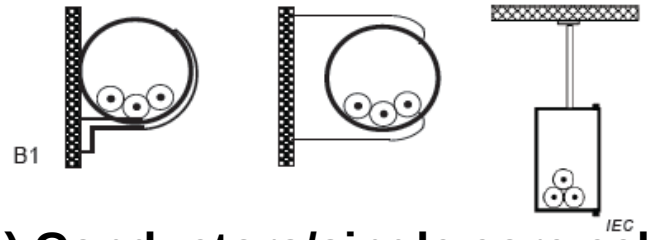
Cross-sectional Area mm^2	Installation method (see D.2.2)			
	B1	B2	C	E
	Current-carrying capacity *Iz* for three phase circuits(A)			
0.75	8.6	8.5	9.8	10.4
1.0	10.3	10.1	11.7	12.4
1.5	13.5	13.1	15.2	16.1
2.5	18.3	17.4	21	22
4	24	23	28	30
6	31	30	36	37
10	44	40	50	52
16	59	54	66	70
25	77	70	84	88
35	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

Annex D (informative)

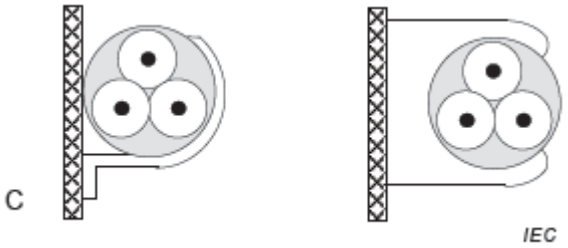
Annex D (informative)
Current-carrying capacity and overcurrent protection of conductors and cables in the electrical equipment of machines
D.1 General
D.2.2 Methods of installation
In machines, the methods of conductor and cable installation between enclosures and
individual items of the equipment shown in Figure D.1 are assumed to be typical (the letters used are in accordance with IEC 60364-5-52):

– **Method B1**: using conduits (3.1.9) and cable trunking systems (3.1.6) for holding and protecting conductors or single core cables;
– **Method B2**: same as B1 but used for multicore cables;
– **Method C**: multicore cables installed in free air, horizontal or vertical without gap between cables on walls;
– **Method E**: multicore cables in free air, horizontal or vertical laid on open cable trays (3.1.5).

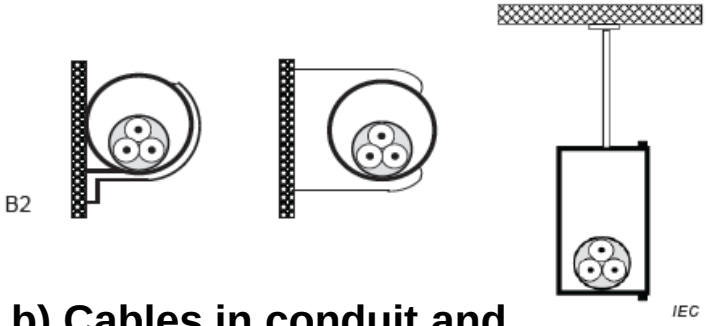
Annex D (informative)



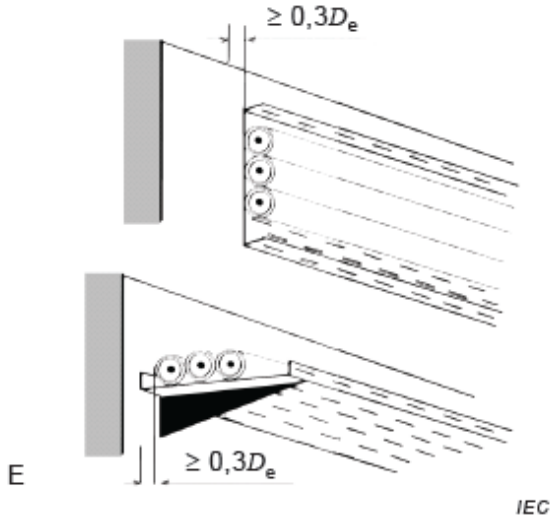
a) Conductors/single core cables in conduit and cable trunking systems



c) Cables on walls



b) Cables in conduit and cable trunking systems



d) Cables on open cable trays

Figure D.1 – Methods of conductor and cable installation

I independent of number of conductors/cables

13 Wiring practices

13.1 Connections and routing

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.

NOTE 1 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 2 Derived from IEC 60364-5-52.

13 Wiring practices

13.2 Identification of conductors

13.2.1 General requirements

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

Where the protective conductor(s) can be easily identified by its shape, position, or construction (for example 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. However, **where the conductor is not clearly visible throughout its length**, the ends or accessible locations shall be clearly identified by the graphical symbol IEC 60417-5019:2006-08 (see Figure 16) **or with the letters PE** or by the bicolour combination GREEN-AND-YELLOW.

13 Wiring practices

13.2 Identification of conductors

13.2.1 General requirements

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

Figure 16 – 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 17).

Figure 17 – Symbol IEC 60417-5021

15 Socket-outlets and lighting

15.1 Socket-outlets for accessories

– where fault protection is provided by automatic disconnection of supply, **the disconnection time shall be in accordance with Table A.1 for TN systems or Table A.2 for TT systems**;

– **circuits supplying socket-outlets with a current rating not exceeding 20 A** shall be provided with residual current protection (RCDs) with a **rated operating current not exceeding 30 mA.**

15.2 Local lighting of the machine and of the equipment

15.2.2 Supply

– power supply units, for DC supply to LED light sources, fitted with **isolating transformers (for example, in accordance with IEC 61558-2-6)**.

16 Marking, warning signs and reference designations

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 (see Figure 18).

Figure 18 – Symbol ISO 7010-W012

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 shall be used (see Figure 19).

Figure 19 – Symbol ISO 7010-W017

17 Technical documentation

17.1 General

The information necessary for **identification, transport**, installation, operation, and use, maintenance, **decommissioning and disposal** of the electrical equipment of a machine shall be supplied

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 if he so wishes 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.

Annex I should be considered as guidance for the preparation of information and documents

Annex I (informative)

Annex I (informative)
Documentation / Information
A list of available standards applicable to documentation and information is provided in Table I.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 I.1 – Documentation / Information that can be applicable

Type of information for the electrical equipment	Recommended standard
Structuring principles	IEC 81346-1: Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 1: Basic rules

17 Technical documentation

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;

17 Technical documentation

17.2 Information related to the electrical equipment

The following shall be supplied:

c) information on installation and mounting including:

- any additional electrical supply(ies) 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;

17 Technical documentation

17.2 Information related to the electrical equipment

The following shall be supplied:

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;

17 Technical documentation

17.2 Information related to the electrical equipment

The following shall be supplied:

f) information on maintenance of the electrical equipment, as appropriate, including:

- frequency and method of functional testing;
- instructions on the procedures for safe maintenance and where it is necessary to suspend a safety function and/or protective measure (see 9.3.6);
- 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;

17 Technical documentation

17.2 Information related to the electrical equipment

The following shall be supplied:

f) information on maintenance of the electrical equipment, as appropriate, including:

- 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

The extent of verification will be given in the dedicated product standard for a particular machine. Where there is no dedicated product standard for the machine, the verifications shall always include the items a), b), c) and h) and may include one or more of the items d) 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, conditions for protection by automatic disconnection shall be verified according to 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 8.2.6 are met;

h) functional tests (see 18.6).

For verifications that include measurement, measuring equipment in accordance with the IEC 61557 series is recommended.

18 Verification

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.

For IT systems, see IEC 60364-6.

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.

Annex A (normative)

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 the Annex A are derived from IEC 60364-4-41:2005, and IEC 60364-6:2006.

A.2 Fault protection for machines supplied from TT-systems

A.2.1 Connection to earth

A.2.2 Fault protection for TT systems

A.2.2.1 General

A.2.2.2 Protection by residual current protective device (RCD)

A.2.2.3 Protection by overcurrent protective devices

A.2.3 Verification of protection by automatic disconnection of supply using a residual current protective device

A.2.4 Measurement of the fault loop impedance (*Zs*)

Annex B (informative)

Annex B (informative)

Enquiry form for the electrical equipment of 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 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 machines.