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(JMF)

**Safety of machinery —
Electrical equipment of machines —
Part 1: General requirements**

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Health, Labour and Welfare and the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by the Japan Machinery Federation (JMF) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS B 9960-1** : 1999 is replaced with this Standard.

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Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Ministers and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

JIS B 9960 consists of the following parts under the general title “*Safety of machinery—Electrical equipment of machines*”:

Part 1: General requirements

Part 11: Requirements for HV equipment for voltages above 1000V a.c. or 1500V d.c. and not exceeding 36kV

Part 31: Particular safety and EMC requirements for sewing machines, units and systems

Part 32: Requirements for hoisting machines

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

Introduction

This Japanese Industrial Standard has been prepared based on the fifth edition of **IEC 60204-1** published in **2005** with some modifications of the technical contents.

The portions given sidelines or dotted underlines and Annex JA to Annex JI are the matters not given in the corresponding International Standard. A list of modifications with the explanations is given in Annex JI.

The guidance on the application of this Standard is given in Annex F.

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

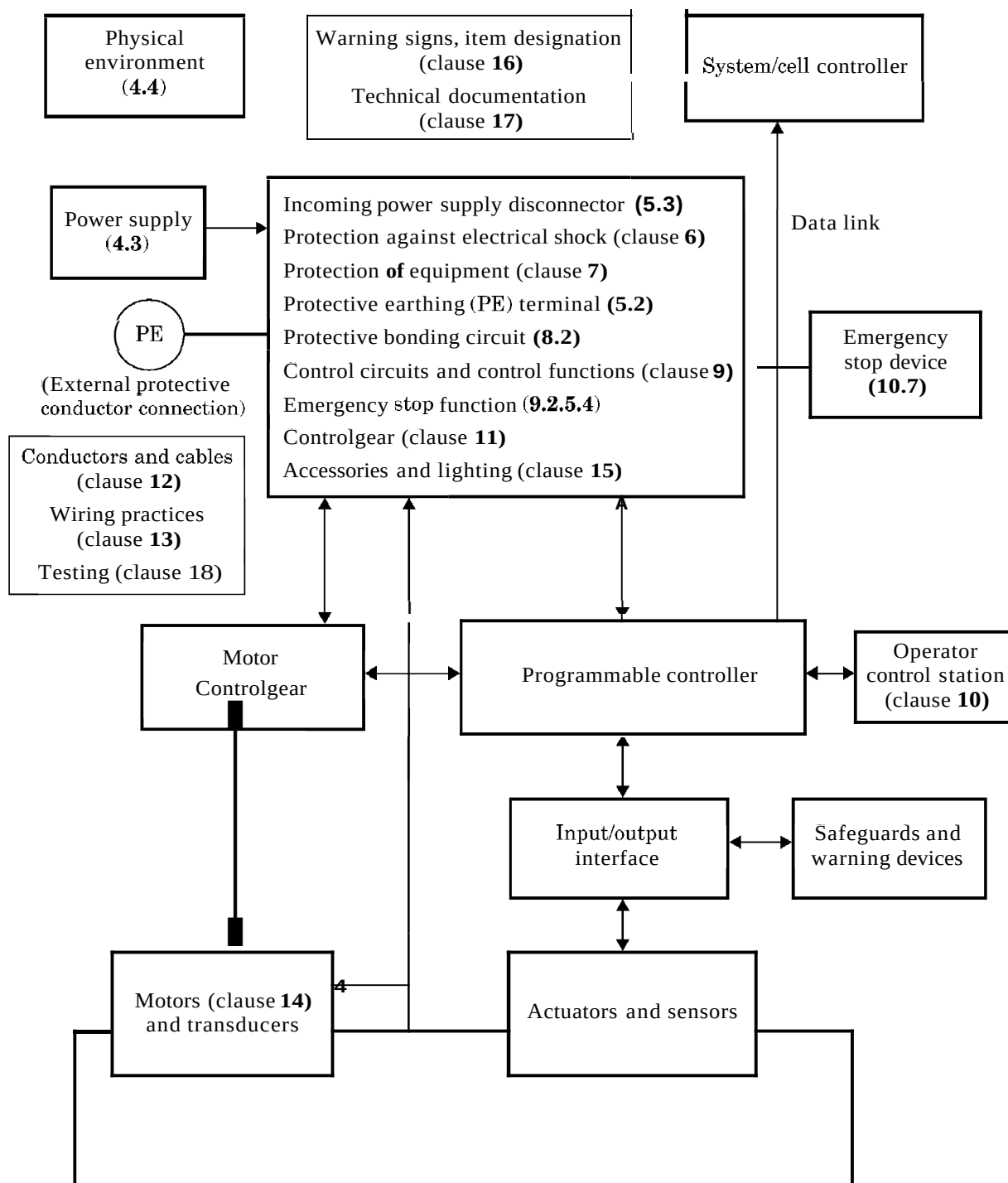


Figure 1 Block diagram of typical machine

1 Scope

This Standard specifies the requirements and recommendations to achieve the following matters relating to the electrical equipment of machines.

- Safety of persons and property
- Consistency of control response
- Ease of maintenance

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

NOTE 1 This Standard is an application standard for technology and is not intended to limit or inhibit technological advancement.

NOTE 2 In this Standard, the term “electrical” includes electrical, electronic and programmable electronic matters (i.e. the electrical equipment includes electrical, electronic and programmable electronic equipment).

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

The equipment covered by this Standard commences at the connecting point of the power supply to the electrical equipment of the machine (see **5.1**).

NOTE 4 The requirements for the power supply facility in buildings are specified in **JIS C 60364** series.

This Standard is applicable to the electrical equipment that operates with nominal power supply voltage of 1000 V or under for alternate current (a.c.) and of 1500 V or under for direct current (d.c.) and with nominal frequencies of 200 Hz or under.

NOTE 5 For higher voltages, requirements are specified in **JIS B 9960-11**.

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

The scope of this Standard specifically includes the electrical equipment of machines as defined in **3.35**, but is not limited to.

NOTE 6 Annex C lists examples of machines using the electrical equipment to which this Standard is applicable.

This Standard does not specify additional and special requirements that can apply to the electrical equipment of machines exemplified as follows.

- That are intended for use in open air (i.e. outside building or other protective structures)
- That use, process, or produce potentially explosive material (for example, paint or swarf)
- That are intended for use in potentially explosive or flammable atmosphere
- That have special risks when producing or using certain materials
- That are intended for use in mines
- Sewing machines, units and systems (specified in **JIS B 9960-31**)
- Hoisting machines (specified in **JIS B 9960-32**)

Power circuits where electrical energy is directly used as a working tool are excluded from this Standard.

NOTE 7 The International Standard corresponding to this Standard is as follows.
IEC 60204-1:2005 *Safety of machinery — Electrical equipment of machines — Part 1: General requirements* (MOD)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. For standards with the year indication, only the editions of the indicated year shall apply but the revisions (including amendments) made thereafter shall not apply. The normative reference without the indication of the year shall apply only to the most recent edition (including amendments).

JIS B 9700-1:2004 *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology*

NOTE : Corresponding International Standard: ISO 12100-1:2003 *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology* (IDT)

JIS B 9700-2:2004 *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles*

NOTE : Corresponding International Standard: ISO 12100-2:2003 *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles* (IDT)

JIS B 9703:2000 *Safety of machinery — Emergency stop — Principles for design*

NOTE : Corresponding International Standard: ISO 13850:1996 *Safety of machinery — Emergency stop — Principles for design* (IDT)

JIS B 9705-1:2000 *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

NOTE : Corresponding International Standard: ISO 13849-1:1999 *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design* (IDT)

JIS B 9706-1:2001 *Safety of machinery — Indication, marking and actuation — Part 1: Requirements for visual, auditory and tactile signals*

NOTE : Corresponding International Standard: IEC 61310-1:1995 *Safety of machinery — Indication, marking and actuation — Part 1: Requirements for visual, auditory and tactile signals* (IDT)

JIS B 9706-2:2001 *Safety of machinery — Indication, marking and actuation — Part 2: Requirements for marking*

NOTE : Corresponding International Standard: IEC 61310-2:1995 *Safety of machinery — Indication, marking and actuation — Part 2: Requirements for marking* (IDT)

JIS B 9706-3:2001 *Safety of machinery— Indication, marking and actuation— Part 3: Requirements for the location and operation of actuators*

NOTE : Corresponding International Standard: IEC 61310-3 :1999 *Safety of machinery— Indication, marking and actuation— Part 3: Requirements for the location and operation of actuators* (IDT)

JIS B 9961 :2008 *Safety of machinery— Functional safety of safety-related electrical, electronic and programmable electronic control systems*

NOTE : Corresponding International Standard: IEC 62061:2005 *Safety of machinery— Functional safety of safety-related electrical, electronic and programmable electronic control systems* (IDT)

JIS C 0365 *Protection against electric shock— Common aspects for installation and equipment*

NOTE : Corresponding International Standard: IEC 61140 *Protection against electric shock— Common aspects for installation and equipment* (IDT)

JIS C 0445 *Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system*

NOTE : Corresponding International Standard: IEC 60445 *Basic and safety principles for man-machine interface, marking and identification—Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system* (IDT)

JIS C 0447 *Man-machine interface (MMI)—Actuating principles*

NOTE : Corresponding International Standard: IEC 60447 *Man-machine interface (MMI)—Actuating principles* (IDT)

JIS C 0448 *Coding of indicating devices and actuators by colours and supplementary means*

NOTE : Corresponding International Standard: IEC 60073 *Basic and safety principles for man-machine interface, marking and identification—Coding principles for indication devices and actuators* (IDT)

JIS C 0452-1:2004 *Industrial system, installations and equipment and industrial products— Structuring principles and reference designations— Part 1: Basic rules*

NOTE : Corresponding International Standard: IEC 61346- 1:1996 *Industrial systems, installations and equipment and industrial products—Structuring principles and reference designations— Part 1: Basic rules* (IDT)

JIS C 0452-2 :2005 *Industrial systems, installations and equipment and industrial products— Structuring principles and reference designations— Part 2: Classification of objects and codes for classes*

NOTE : Corresponding International Standard: IEC 61346-2 :2000 *Industrial systems, installations and equipment and industrial products—Structuring principles and reference designations— Part 2: Classification of objects and codes for classes* (IDT)

JIS C 0453 :2005 *Preparation of parts lists*

NOTE : Corresponding International Standard: IEC 62027 :2000 *Preparation of parts lists* (IDT)

JIS C 0457 :2006 *Preparation of instructions— Structuring, content and presentation*

NOTE : Corresponding International Standard: IEC 62079 :2001 *Preparation of instructions— Structuring, content and presentation* (IDT)

JIS C 0617 (series) *Graphical symbols for diagrams*

NOTE : Corresponding International Standard: IEC 60617 (series) *Graphical symbols for diagrams* (IDT)

JIS C 0664 :2003 *Insulation coordination for low-voltage equipment Part 1: Principles, requirements and tests*

NOTE : Corresponding International Standard: IEC 60664-1 :1992 *Insulation coordination for equipment within low-voltage systems— Part 1: Principles, requirements and tests* (MOD)

JIS C 0920 :2003 *Degrees of protection provided by enclosures (IP Code)*

NOTE : Corresponding International Standard: IEC 60529 :2001 *Degrees of protection provided by enclosures (IP Code)* (IDT)

JIS C 1082-1:1999 *Preparation of documents used in electrotechnology— Part 1: General requirements*

NOTE : Corresponding International Standard: IEC 61082-1 :1991 *Preparation of documents used in electrotechnology— Part 1: General requirements* (including Amendment 1 and Amendment 2) (MOD)

JIS C 1082-2:1999 *Preparation of documents used in electrotechnology— Part 2: Function-oriented diagrams*

NOTE : Corresponding International Standard: IEC 61082-2 :1993 *Preparation of documents used in electrotechnology— Part 2: Function-oriented diagrams* (IDT)

JIS C 1082-3:1999 *Preparation of documents used in electrotechnology— Part 3: Connection diagrams, tables and lists*

NOTE : Corresponding International Standard: IEC 61082-3 :1993 *Preparation of documents used in electrotechnology— Part 3: Connection diagrams, tables and lists* (IDT)

JIS C 1082-4:1999 *Preparation of documents used in electrotechnology— Part 4: Location and installation documents*

NOTE : Corresponding International Standard: IEC 61082-4 :1996 *Preparation of documents used in electrotechnology— Part 4: Location and installation documents* (IDT)

JIS C 2811 *Terminal blocks for industrial and similar use*

NOTE : Corresponding International Standard: IEC 60947-7-1 :1939 *Low-voltage switchgear and controlgear—Part 7-1: Ancillary equipment— Terminal blocks for copper conductors* (MOD)

JIS C 4034-1 *Rotating electrical machines Part 1: Rating and performance*

NOTE : Corresponding International Standard: IEC 60034-1 *Rotating electrical machines — Part 1: Rating and performance* (NEQ)

JIS C 4034-5 *Rotating electrical machines — Part 5: Classification of degrees of protection provided by enclosures of rotating electrical machines (IP code)*

NOTE : Corresponding International Standard: IEC 60034-5 *Rotating electrical machines — Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) — Classification* (IDT)

JIS C 4203:2001 *Single phase induction motors for general purpose*

NOTE : Corresponding International Standards:

IEC 60072-1:1991 *Dimensions and output series for rotating electrical machines — Part 1: Frame numbers 56 to 400 and flange numbers 55 to 1080* (MOD)

IEC 60034-1:1996 *Rotating electrical machines — Part 1: Rating and performance* (MOD)

JIS C 4210:2001 *Low-voltage three-phase squirrel-cage induction motors for general purpose*

NOTE : Corresponding International Standards:

IEC 60072-1:1991 *Dimensions and output series for rotating electrical machines — Part 1: Frame numbers 56 to 400 and flange numbers 55 to 1080* (MOD)

IEC 60034-1:1996 *Rotating electrical machines — Part 1: Rating and performance* (MOD)

IEC 60034-2:1972 *Rotating electrical machines — Part 2: Methods for determining losses and efficiency of rotating electrical machinery from tests* (MOD)

IEC 60034-9:1997 *Rotating electrical machines — Part 9: Noise limits* (MOD)

IEC 60034-12:1972 *Rotating electrical machines — Part 12: Starting performance of single-speed three-phase cage induction motors for voltage up to and including 660 V* (MOD)

JIS C 4212:2000 *Low-voltage three-phase squirrel-cage high efficiency induction motors*

NOTE : Corresponding International Standard: IEC 60072-1:1991 *Dimensions and output series for rotating electrical machines — Part 1: Frame numbers 56 to 400 and flange numbers 55 to 1080* (MOD)

JIS C 60364-4-41:2006 *Electrical installations of buildings — Part 4-41: Protection for safety — Protection against electric shock*

NOTE : Corresponding International Standard: IEC 60364-4-41:2001 *Electrical installations of buildings — Part 4-41: Protection for safety — Protection against electric shock* (IDT)

JIS C 60364-4-43:2006 *Electrical installations of buildings—Part 4-43: Protection for safety—Protection against overcurrent*

NOTE : Corresponding International Standard: IEC 60364-4-43:2001 *Electrical installations of buildings—Part 4-43: Protection for safety—Protection against overcurrent* (IDT)

JIS C 60364-5-52:2006 *Electrical installations of buildings—Part 5-52: Selection and erection of electrical equipment—Wiring systems*

NOTE : Corresponding International Standard: IEC 60364-5-52:2001 *Electrical installations of buildings—Part 5-52: Selection and erection of electrical equipment—Wiring systems* (IDT)

JIS C 60364-5-53:2006 *Electrical installations of buildings—Part 5-53: Selection and erection of electrical equipment—Isolation, switching and control*

NOTE : Corresponding International Standard: IEC 60364-5-53:2001 *Electrical installations of buildings—Part 5-53: Selection and erection of electrical equipment—Isolation, switching and control* (IDT)

JIS C 60364-5-54:2006 *Electrical installations of buildings—Part 5-54: Selection and erection of electrical equipment—Earthing arrangements, protective conductors and protective bonding conductors*

NOTE : Corresponding International Standard: IEC 60364-5-54:2002 *Electrical installations of buildings—Part 5-54: Selection and erection of electrical equipment—Earthing arrangements, protective conductors and protective bonding conductors* (IDT)

JIS C 60364-6-61:2006 *Electrical installations of buildings—Part 6-61: Verification—Initial verification*

NOTE : Corresponding International Standard: IEC 60364-6-61:2001 *Electrical installations of buildings—Part 6-61: Verification—Initial verification* (IDT)

JIS C 8201-1 *Low-voltage switchgear and controlgear—Part 1: General rules*

NOTE : Corresponding International Standard: IEC 60947-1 *Low-voltage switchgear and controlgear—Part 1: General rules* (MOD)

JIS C 8201-2-1:2004 *Low-voltage switchgear and controlgear—Part 2-1: Circuit-breakers*

NOTE : Corresponding International Standard: IEC 60947-2:2003 *Low-voltage switchgear and controlgear—Part 2: Circuit-breakers* (MOD)

JIS C 8201-2-2:2004 *Low-voltage switchgear and controlgear—Part 2-2: Circuit-breakers incorporating residual current protection*

NOTE : Corresponding International Standard: IEC 60947-2:2003 *Low-voltage switchgear and controlgear—Part 2: Circuit-breakers (Annex B)* (MOD)

JIS C 8201-3 *Low-voltage switchgear and controlgear—Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*

NOTE : Corresponding International Standard: IEC 60947-3 *Low-voltage switchgear and controlgear—Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units* (MOD)

JIS C 8201-5-1 *Low-voltage switchgear and controlgear—Part 5-1: Control circuit devices and switching elements—Electromechanical control circuit devices*

NOTE : Corresponding International Standard; IEC 60947-5-1 *Low-voltage switchgear and controlgear—Part 5-1: Control circuit devices and switching elements—Electromechanical control circuit devices* (MOD)

JIS C 8285-1 *Plugs, socket-outlets and couplers for industrial purposes—Part 1: General requirements*

NOTE : Corresponding International Standard: IEC 60309-1 *Plugs, socket-outlets, and couplers for industrial purposes—Part 1: General requirements* (MOD)

ISO 7000:2004 *Graphical symbols for use on equipment—Index and synopsis*

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

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

IEC 60072-2:1990 *Dimensions and output series for rotating electrical machines—Part 2: Frame numbers 355 to 1000 and flange numbers 1180 to 2360*

IEC 60417-DB:2002 *Graphical symbols for use on equipment*

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

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

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

IEC 60895:1995 *Electrical accessories—Circuit-breakers for overcurrent protection for household and similar installations*

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

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

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

IEC 61558-1:1997 *Safety of power transformers, power supply units and similar—Part 1: General requirements and tests, Amendment 1 (1998)*

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

IEC 61984:2001 *Connectors—Safety requirements and tests*

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

3 Terms and definitions

For the purposes of this Standard, the following terms and definitions shall apply.

3.1 actuator

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

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

NOTE 2 Some actuating means do not require an external actuating force but only an action of region of body (hand, foot, etc.).

NOTE 3 See also 3.34.

3.2 ambient temperature

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

3.3 barrier

part providing protection against direct contact from any usual direction of access (according to **IEV 826-03-13**)¹⁾

Note ¹⁾ IEC: International Electrotechnical Vocabulary is specified in **IEC 60050**, and **IEV 826-03-13** is corresponding to **IEC 60050-826-03-13** (hereafter, in the same manner).

3.4 cable tray

cable support consisting of a continuous base and raised edges and no covering (according to **IEV 826-15-08**).

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

3.5 cable trunking system

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

3.6 concurrent actuation

actuation performed concurrently

It is used to describe a situation wherein two or more control devices are actuated at the same time (but not necessarily synchronously).

3.7 conduit

closed wiring part of circular or non-circular cross-section for insulated conductors or cables in electrical installations allowing them to be drawn in and/or replaced (according to **IEV 826-06-03**)

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

3.8 control circuit (of a machine)

circuit used for controlling (including monitoring) the machine and the electrical equipment

3.9 control device

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

3.10 controlgear

switching devices and their combination with associated control, measuring, protective, and regulating equipment, and also assemblies of such devices and equipment associated with interconnections, accessories, enclosures and supporting structures, intended in principle for the control of electrical energy consuming equipment (**IEV 441-11-03** is modified)

3.11 controlled stop

stopping of machine with power supply to the machine actuators maintained during the stopping process

3.12 direct contact

contact of persons or livestock with live parts (according to **IEV 826-12-03**)

3.13 direct opening action (of a contact element)

achievement of contact separation as the direct result of a specified movement of the switch actuator through non-resilient members (for example, not dependent upon springs) (according to **K.2.2** of **JIS C 8201-5-1**)

3.14 duct

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

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

3.15 electrical operating area

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

3.16 electronic equipment

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

3.17 emergency stop device

control device manually actuates an emergency stop function (according to **3.2** of **JIS B 9703**)

NOTE : See Annex E.

3.18 emergency switching off device

control device manually breaks 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.

3.19 enclosed electrical operating area

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

3.20 enclosure

part providing protection of electrical equipment against certain external influences and protection against direct contact from any direction

NOTE : The following explanations are added so that the definition taken from the existing **IEV** is applicable to this Standard.

- a) Enclosures provide protection of persons or livestock against access to hazardous parts.
- b) Barriers, shaped openings or any other means suitable to prevent or limit the penetration of the specified test probes, whether attached to the enclosure or formed by the enclosed equipment, are considered as part of the enclosure except for those removable without the use of a key or tool.
- c) The following shall also be regarded as the enclosure.
 - A cabinet or box, either mounted on the machine or separated from the machine
 - A compartment consisting of an enclosed space within the machine structure (see **13.5.7**).

3.21 equipment

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

3.22 equipotential bonding

provision of electric connections between conductive parts intended to achieve equipotentiality (according to **IEV 195-1-10**)

3.23 exposed conductive part

touchable conductive part of electrical equipment which is not live under normal operating conditions, but can become live under fault conditions (insulation failure) (**IEV 826-12-10** is modified)

3.24 extraneous conductive part

conductive part not forming the electrical installation and liable to introduce a potential, generally the earth potential (**IEV 826-12-11** is modified)

3.25 failure

termination of the ability of an item²⁾ to perform a required function

Note ²⁾ An item means the generic term of, or any one of, a part, component, device, equipment, functional unit, instrument? subsystem and system targeted for the dependability. The item consists of hardware, software or both of them.

NOTE 1 After failure, the item has a fault (state).

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

NOTE 3 This concept as defined does not apply to the items consisting of software only (according to **IEV 191-04-01**).

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

3.26 fault

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

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

NOTE 2 In English, the term “fault” may mean the insulation failure or the ground fault. In **IEC 60204-1**, “fault” is often used in this meaning.

3.27 functional bonding

equipotential bonding necessary for proper functioning of electrical equipment

3.28 hazard

potential source of physical injury or damage to health

NOTE 1 The term “hazard” may be qualified in order to define its origin (for example, mechanical hazard, electrical hazard) or the nature of the potential harm (for example, electric shock hazard, cutting hazard, toxic hazard, fire hazard).

NOTE 2 In this definition? the following is envisaged as hazards.

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

(3.6 of **JIS B 9700-1** is modified)

3.29 indirect contact

contact of persons or livestock with exposed conductive parts which have become live under insulation failure (according to **IEV 826-12-04**)

3.30 inductive power supply system

system of inductive power supply consisting of a track converter and a track conductor along which one or more pick-ups and associated pick-up converter can move and

capable of feeding without any electric or mechanical contact, for example, to a mobile machine

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

3.31 (electrically)instructed person

person adequately advised or supervised by an electrically skilled person to enable him or her to perceive risks and to avoid hazards which electricity can create (**IEV 826-18-02** is modified)

3.32 interlock (for safeguarding)

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

3.33 live part

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

NOTE : This term does not necessarily imply the conductor having a risk of electric shock.

3.34 machine actuator

driving mechanism used to actuate the machine

3.35 machinery, machine

combination 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 material

The term “machinery” also covers an assembly of machines which, in order to achieve the same purpose, are arranged and controlled so that they function as an integral whole (**3.1** of **JIS B 9700-1** is modified).

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

3.36 marking

signs or inscriptions primarily for the purpose of identifying equipment, components and/or devices (including certain features thereof)

3.37 neutral conductor, N

conductor connected to the neutral point of a power supply system and capable of contributing to the transmission of electrical energy (**IEV 826-14-07** is modified)

3.38 obstacle

structure preventing unintentional direct contact but not preventing direct contact by deliberate action

3.39 overcurrent

current exceeding the rated value

The rated value of conductor refers to the permissible current-carrying capacity (**IEV 826-11-14** is modified)

3.40 overload (of a circuit)

amount (I^2t) related to time and current in a circuit which is in excess of the rated load of the circuit when the circuit is not under a fault condition

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

3.41 plug/socket combination

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

NOTE : Examples of plug/socket combination are as follows.

- Connectors satisfying the requirements of **IEC 61984**
- A plug and socket-outlet, a cable coupler or an appliance coupler in accordance with **JIS C 8285-1**
- A plug and socket-outlet in accordance with **IEC 60884-1** or an appliance coupler (power supply connector) in accordance with **IEC 60320-1**

3.42 power circuit

circuit that supplies power from the power supply network to each part of equipment for production and to transformers for control

3.43 protective bonding

equipotential bonding for protection against electric shock

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

3.44 protective bonding circuit

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

3.45 protective conductor

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

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

(**IEV 826-13-22** is modified)

3.46 redundancy

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

3.47 reference designation

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

NOTE : The term “reference designation” used in this Standard corresponds to the term “reference designation” of **JIS C 0452-1**.

3.48 risk

combination of the probability of occurrence of harm (i.e. physical injury or damage to health) and the severity of that harm (**3.11** of **JIS B 9700-1** is modified)

3.49 safeguard

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

3.50 safeguarding

protective measure using safeguards to protect persons from the hazards which cannot reasonably be eliminated or from the risks which cannot be sufficiently reduced by inherently safe design measures (according to **3.20** of **JIS B 9700-1**)

3.51 servicing level

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

3.52 short-circuit current

overcurrent resulting from a short-circuit due to a fault or an incorrect connection in an electric circuit (according to **IEV 441-11-07**)

3.53 (electrically) skilled person

person with relevant training, education and experience to enable him or her to avoid hazards associated with electricity (**IEV 826-18-01** is modified)

3.54 supplier

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

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

3.55 switching device

device designed to make and/or break the current in one or more electric circuits (**IEV 441-14-01** is modified)

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

3.56 uncontrolled stop

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

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

3.57 user

entity (individual or group) who utilizes the machine and its associated electrical equipment

4 General requirements

4.1 General consideration

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

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

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

- Failures or faults in the electrical equipment resulting in the possibility of electric shock or electrical fire
- Failures or faults in control circuits (or components and devices thereof) resulting in the malfunctioning of the machine
- Fluctuation or loss in power supply as well as failures or faults in power circuit resulting in the malfunctioning of the machine
- Loss of continuity of contact circuits that depend upon sliding or rolling contacts, resulting in failure of safety function
- Electrical disturbance (for example, electromagnetic disturbance, electrostatic) either from outside the electrical equipment or internally generated, resulting in the malfunctioning of the machine
- Release of stored energy (either electrical or mechanical) resulting in, for example, unexpected movement that may cause electric shock or injury
- Audible noise at levels that cause health problems to persons
- Surface temperatures that may cause injury

Safety measures are a combination of the measure incorporated by the supplier of the electrical equipment 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 the risks cannot be sufficiently reduced by inherently safe design measures, protective measures (for example, safeguarding) shall be provided to reduce the risk. Additional means (for example, awareness means) shall be provided where further risk reduction is necessary. In addition, working procedures that reduce the risk can be necessary.

The use of the enquiry form as shown in Annex B is recommended in order to facilitate an appropriate agreement between the user and the supplier on basic conditions and additional user specifications related to the electrical equipment. The purpose to designate the additional specification in the enquiry shall be as follows.

- Provide additional feature that are dependent on the type of machine (or group of machines) and the application
- Facilitate maintenance and repair
- Improve the reliability and ease of operation

4.2 Selection of equipment

4.2.1 General

Electrical components and electrical devices used for the electrical equipment of machine shall satisfy all of the following.

- Suitable for the intended use
- Conforming to relevant Japanese Industrial Standards and **IEC** Standards where such exist
- Used in accordance with the supplier's instructions

4.2.2 Electrical equipment conforming to IEC 60439 series

The electrical equipment of machine shall satisfy the safety requirements identified by the risk assessment of the machine. Depending upon the machine, its intended use and its electrical equipment, the designer may select parts of the electrical equipment of the machine that conform to **IEC 60439** series (see Annex Fj).

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

4.3 Power supply

4.3.1 General

The electrical equipment shall be designed to operate correctly with one of the following power supply conditions.

- That given in **4.3.2** or **4.3.3**
- That specified by the user (see Annex B)
- That specified by the supplier (in the case of a special source of power supply such as an on-board generator)

4.3.2 AC power supply

Voltage	0.9 to 1.1 of nominal voltage under steady state
Frequency	0.99 to 1.01 (continuity) or 0.98 to 1.02 (short time) of nominal frequency of power supply
Harmonics	Harmonics distortion (content) shall be 10 % or under of total r.m.s. voltage between live conductors for the sum of the second harmonic through the fifth harmonic, and 2 % or under of total r.m.s. voltage between live conductors for the sum of the sixth harmonic through the thirtieth harmonic.
Voltage unbalance	Neither the voltage of the negative sequence component nor the voltage of the zero sequence component in three-phase power supplies exceeding 2 % of the positive sequence component.

Voltage interruption	Power supply interrupted or at zero voltage for 3 ms or under at any random time in the power supply cycle with over 1s between successive interruptions
Voltage dips	Voltage dips shall be 20 % or under of the peak voltage of power supply for one cycle or under with over 1s between successive dips

4.3.3 DC power supply

Battery power supply

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	5 ms or under

Converter power supply

Voltage	0.9 to 1.1 of nominal voltage
Voltage interruption	20 ms or under with over 1s between successive interruptions

NOTE : The value in **IEC Guide 106** (specified value of 500 ms) is modified to ensure proper operation of electrical equipment.

Ripple (p-p value)	0.15 or under of nominal voltage
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4.3.4 Special power supply systems

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

4.4 Physical environment and operating conditions

4.4.1 General

The electrical equipment shall be suitable for the physical environment and operating conditions of the site where it is intended to be operated. The requirements of 4.4.2 to 4.4.8 specify the physical environment and operating conditions of the majority of machines covered by this Standard. When the special conditions apply or the limits of environmental and operating conditions exceed the specifications of this Standard, an agreement between the user and the supplier (see 4.1) may be necessary.

4.4.2 Electromagnetic compatibility (EMC)

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

NOTE 1 The generic EMC standards **JIS C 61000-6-1** and **JIS C 61000-6-2**, and **CISPR 61000-6-3** and **IEC 61000-6-4** give general EMC immunity and emission 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 (for example, **JIS B 9704-1**, **IEC 61800-3**, **JIS C 8201-5-2**) exist, they take precedence over these generic standards.

Measures to limit the generation of electromagnetic disturbances, i.e. conducted and radiated emissions shall be as follows.

- Power supply filtering
- Cable shielding
- Enclosures designed to minimize RF radiation
- RF radiation suppression techniques

Measures to enhance the immunity of equipment against conducted and radiated RF disturbance are as follows.

- Design of functional bonding system taking into account the following
 - Sensitive electrical circuits shall be connected to the chassis. Such connecting terminals shall be marked or labelled by the following symbol of **IEC 60417-5020** (DB:2002-10).



- Connection of the chassis to protective earthing (PE) conductor using a conductor with low RF impedance and as short as practicable
- Sensitive electrical equipment or circuits shall be directly connected to PE conductor or to a functional earthing conductor (FE) (see figure 2) to minimize the common mode disturbance. This FE terminal shall be marked or labelled by the following symbol of **IEC 60417-5018** (DB:2002-10).



- Sensitive circuits shall be separated from the disturbance sources.
- Enclosures designed to minimize RF transmission shall be used.
- Effective wiring method for EMC shall be employed.
 - Using twisted conductors to reduce the effect of differential (normal) mode disturbances
 - Keeping sufficient distance between the conductors emitting disturbances and conductors of sensitive circuits
 - Using cable orientation as close to 90° as practicable when cables cross
 - Wiring conductors as close as practicable to the ground plane
 - Using electrostatic screens and/or electromagnetic shields with a low RF impedance termination.

4.4.3 Ambient air temperature

Electrical equipment shall be capable of operating correctly in the intended ambient temperature. The minimum requirement for all electrical equipment is correct operation between ambient temperatures of 5 °C and 40 °C.

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

4.4.4 Humidity

The electrical equipment shall be capable of operating correctly when the relative humidity is 50 % or under at a maximum temperature of +40 °C. Higher relative humidities are permissible at lower temperatures (for example, 90 % at +20 °C).

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

4.4.5 Altitude

Electrical equipment shall be capable of operating correctly at altitudes up to 1000 m above sea level. A special agreement (for example, on correct operation at altitudes of 1000 m or higher above sea level) may be necessary between the supplier and the user (see Annex B).

4.4.6 Contaminants

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

The electrical equipment shall be adequately protected against contaminants (for example, dusts, 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 electrical equipment is subject to radiation (for example, microwave, ultra-violet, lasers, X-rays), additional measures shall be taken to avoid malfunctioning of the equipment and accelerated deterioration of the insulation. A special agreement in regard to this matter may be necessary between the supplier and the user (see Annex B).

4.4.8 Vibration, **shock**, and bump

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

4.5 Transportation and storage

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

NOTE : PVC insulated cables are susceptible to damage at low temperature.

4.6 Means for convenience of handling

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

4.7 Installation

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

5 Connection of incoming power supply conductors, disconnectors and devices for switching off

5.1 Connection of incoming power supply conductors

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

Unless a plug is provided with the machine for the connection to the incoming power supply conductor [see **5.3.2 e**)], the power supply conductor should be directly connected to the power supply disconnector.

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

There shall be no connection between the neutral conductor (N) and the protective bonding circuit (PE) inside the electrical equipment. In addition, the PEN terminal which serve a double purpose of the PE terminal and the N terminal shall not be provided.

Exception : A connection may be made between the N terminal and the PE terminal at the connecting point of the power supply to the machine in the TN-C earthing system³⁾.

Note ³⁾ The TN-C earthing system is one of the earthing systems of power supply and makes the PEN conductor serve a double purpose of the PE conductor and the N conductor in the TN earthing system. For the commercial power supply in Japan, the TT earthing system is used, but the TN earthing system is not. For the earthing system of power supply, there is a description in article 272 of the "interpretation of technical standards for electrical installations", the document published by the Ministry of Economy, Trade and Industry.

All terminals for the incoming power supply connection shall be clearly identified in accordance with **JIS C 0445** or **IEC 60445**, and **16.1**. For the identification of the external protective conductor terminal, see **5.2**.

NOTE : **JIS C 0445** :1999 (identical with **IEC 60445** :1988) is slightly different from **IEC 60445** :1999, which is quoted in **IEC 60204-1 :2005** (In **JIS C 0445**:1999, there is no specification on the FE terminal and the FB terminal).

5.2 Terminal for connection to external protective earthing system

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

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

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

NOTE : The size of the terminal for connecting the external protective conductor (PE terminal) shall be determined in accordance with the following procedure.

- Determine the cross-sectional area of the external protective conductor from the cross-sectional area of the phase conductor of power supply in accordance with table 1.
- From the determined cross-sectional area of the external protective conductor, determine the size of the PE terminal to which this protective conductor is connected.

Table 1 Minimum cross-sectional area of external protective conductor (copper)

Cross-sectional area of phase conductor of power supply feeding for equipment S (mm ²)	Minimum cross-sectional area of the external protective conductor (copper) S_p (mm ²) (S_p is determined corresponding to S in left column)
$S \leq 16$	S
$16 < S \leq 35$	16
$S > 35$	$S/2$

At each incoming power supply point, the terminal for the external protective earthing system or the external protective conductor shall be marked or labelled with the letters PE (see **JIS C 0445** or **IEC 60445**).

5.3 Incoming power supply disconnecter

5.3.1 General

An incoming power supply disconnecter shall be set for the following power supply.

- Each incoming power supply to machine

NOTE 1 The incoming power supply may be connected directly to the machine or via a feeder system. In the feeder systems, the conductor wires, conductor bars, slip-ring assemblies, flexible cable systems (reeled, festooned) and inductive power supply systems may be included.

— Each on-board power supply

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

When more than one disconnecter is provided, the protective interlock for correct operation shall also be provided in order to prevent a hazardous situation (including damage to the machine or to the work in progress, see NOTE 2).

NOTE 2 The definition of “hazardous situation” is described in 3.9 of JIS B 9700-1 as follows.

“Circumstance in which a person is exposed to at least one hazard, and the exposure can immediately or over a period of time result in harm.”

5.3.2 Type

For the incoming power supply disconnecter, one of the following types shall be used.

- a) Switch-disconnector, with or without fuses, conforming to JIS C 8201-3 or IEC 60947-3, utilization category AC-23B or DC-23B

NOTE : JIS C 8201-3:2001 is corresponding to IEC 60947-3:1990 (MOD) and is not the same as IEC 60947-3:1999, which is quoted in IEC 60204-1:2005. Ditto for b) below.

- b) Disconnector, with or without fuses conforming to JIS C 8201-3 or IEC 60947-3, that has an auxiliary contact to break the load circuit with other switching devices in all cases before the opening of the main contacts of the disconnector
- c) A circuit-breaker suitable for isolation conforming to JIS C 8201-2-1 or JIS C 8201-2-2
- d) Any other switching device conforming to the relevant Japanese Industrial Standard or IEC Standard for that product and which meets the isolation requirements of JIS C 8201-1 as well as a utilization category defined in that product standard as appropriate for on-load switching of motors or other inductive loads
- e) Plug/socket combination for a flexible cable for feeding

5.3.3 Requirements

When the input power supply disconnecter is one of the types given in 5.3.2 a) to d), it shall satisfy all of the following requirements.

- Capable of isolating the electrical equipment from the power supply and have one OFF (isolated) position and one ON (closed) position marked with “○” and “|” [Symbols in accordance with IEC 60417-5008 (DB:2002-10) and IEC 60417-5007 (DB:2002-10). See 10.2.2].

- Having 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.
- Having an external operating means (for example, handle) on the enclosure of disconnector (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 should be coloured black or grey (see **10.7.4** and **10.8.4**).
- Being provided with a means permitting it to be locked in the OFF (isolated) position (for example, by padlocks). When so locked, remote as well as local closing shall be prevented.
- Capable of disconnecting all live conductors of its power supply circuit. However, when the power is supplied in the TN-S earthing system⁴⁾, the neutral conductor may or may not be disconnected. In any earthing system, the PE conductor and the PEN conductor shall not be disconnected.

Note ⁴⁾ The TN-S earthing system is a system in which the PE conductor and the N conductor (neutral conductor) are separated in the TN supply system. The TN-S earthing system is not used for the commercial power supply in Japan.

- Having a breaking capacity sufficient to interrupt the current of the largest motor when stalled together with the sum of the normal operating currents of all other motors and/or loads.

The calculated breaking capacity may be reduced by the use of a proven diversity factor.

When the incoming power supply disconnector is a plug/socket combination, it shall satisfy the following requirements.

- Having the switching capability itself, 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 operating currents of all other motors and/or loads.

The calculated breaking capacity may be reduced by the use of a proven diversity factor. When the interlocked switching device is electrically operated (for example, a contactor), it shall have an appropriate utilization category.

- **a) to f) of 13.4.5.**

NOTE : A suitably rated plug and socket-outlet, cable coupler or coupler for appliance conforming to **JIS C 8285-1** can satisfy these requirements.

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

5.3.4 Operating means

The operating means (for example, a handle) of the incoming power supply disconnector shall be easily accessible and positioned 0.6 m or over up to and including 1.9 m above the servicing level. An upper limit of 1.7 m is recommended.

NOTE : The direction of operation is specified in **JIS B 9706-3**.

5.3.5 Excepted circuits

The following circuits need not be disconnected by the incoming power supply disconnecter.

- Power supply circuits for lighting needed during maintenance or repair
- Plug and socket-outlets for the exclusive connection of repair or maintenance tools and equipment (for example, hand drills, testing equipment)
- Undervoltage protection circuits provided only for automatic tripping in the event of power supply failure
- Feeding circuit for equipment that should normally remain energized for correct operation [for example, temperature controlled measuring devices, product (work in progress) heaters, program storage devices]
- Control circuits for interlocking

However, such circuits should be provided with their own disconnecter.

In the case where such a circuit is not disconnected by the incoming power supply disconnecter, the following requirements shall be satisfied.

- Permanent warning label(s) shall be appropriately placed in the vicinity of the incoming power supply disconnecter
- A corresponding statement shall be included in the maintenance manual, and one or more of the following shall apply.
 - A permanent warning label in accordance with **16.1** shall be placed in the vicinity of each excepted circuit
 - The excepted circuit is separated from other circuits
 - The conductors are identified by colour taking into account the recommendation of **13.2.4**.

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

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

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

NOTE 1 Details of prevention of unexpected start-up shall be specified in **JIS B 9714**. This Standard does not address all provisions for prevention of unexpected start-up.

NOTE 2 The definition and explanation of unexpected start-up is also described in **3.29** of **JIS B 9700-1**. The start made by an operator who pushes the start button of a control station without knowing that a maintenance person is intervening in the machine is an unexpected start-up from the standpoint of the maintenance person. The device for switching off for prevention of unexpected start-up is a device for disabling the machine

to start-up while this is opened. For example, the machine does not start-up even if someone pushes a start button accidentally, if this device is opened during the maintenance service.

NOTE 3 It is given in **5.4** that all machines are not always required to be provided with the device for switching off for prevention of unexpected start-up further in addition to the input power supply disconnecter given in **5.3**. Depending on the machine (electrical equipment), unexpected start-up may be prevented by opening the incoming power supply disconnecter.

Means shall be provided to prevent inadvertent or mistaken closure of the devices for switching off to prevent unexpected start-up either at the operator control station or from other places (see also **5.6**).

The following devices satisfying the disconnecting function may be used as the device for switching off to prevent unexpected start-up.

- Device indicated in **5.3.2**
- Other disconnectors, withdrawable fuse links or withdrawable links only if located in an enclosed electrical operating area (see **3.19**).

Devices not satisfying the disconnecting function (for example, a contactor switched-off by a control circuit) shall not be used other than the case intended to be used for the following situations.

- Inspections
- Adjustments
- Work on the electrical equipment which satisfies the following conditions
 - There is no hazard arising from electric shock (see clause **6**) and burn.
 - The switching off means remains effective throughout the work.
 - The work is of a minor nature (for example, replacement of plug-in devices without disturbing existing wiring).

NOTE 4. The selection of a device will be dependent on the risk assessment by taking into account the intended use of the device. For example, the use of disconnectors, withdrawable fuse links or withdrawable links located in enclosed electrical operating areas can be inappropriate for use by cleaners [see **17.2 b) 12**].

5.5 Devices for disconnecting electrical equipment

NOTE : The “electrical equipment” given in **5.5** is not the electrical equipment as an aggregate including all electric parts of a machine, but for example, the individual part such as each power circuit, a transformer, a motor, a control circuit (see **3.21**). Although the “devices for disconnecting electrical equipment” required here are basically assumed to be provided separately from the incoming power supply disconnecter given in **5.3**, for the simple machine (electrical equipment), even if it is not provided separately from the incoming power supply disconnecter, the incoming power supply disconnecter may be capable of performing this function. Whether an independent disconnecter should be provided or not depends on the risk assessment.

Devices shall be provided for disconnecting (isolating) electrical equipment to enable work to be performed when it is de-energized and isolated. Such devices shall be as follows.

- Appropriate and convenient for the intended use
- Suitably located
- Readily identifiable as to which part(s) or circuit(s) of the equipment is served (for example, by durable marking).

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

The incoming power supply disconnecter (see **5.3**) may, in some cases, satisfy the disconnecting function given in **5.5**. However, where it is necessary to work on individual parts of the electrical equipment of a machine, or on one of a number of machines fed by a common conductor bar, conductor wire or inductive power supply system, a disconnecter shall be provided for each part or for each machine requiring separate disconnection.

In addition to the incoming power supply disconnecter, the following devices satisfying the disconnecting function may be used.

- Devices indicated in **5.3.2**
- Other disconnectors, withdrawable fuse links and withdrawable links only if located in an electrical operating area (see **3.15**) and relevant information is provided with the electrical equipment [see **17.2 b) 9)** and **17.2 b) 12)**].

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

5.6 Protection against unauthorized, inadvertent/mistaken connection

The devices given in **5.4** and **5.5** located outside an enclosed electrical operating area shall be provided with means to secure them in the OFF position (disconnected state) (for example, padlocking, trapped key interlocking). When so secured, remote as well as local power restore shall be prevented.

Where a non-lockable disconnecter (for example, withdrawable fuse-links, withdrawable links) is located inside an enclosed electrical operating, other means of protection against the power restore (for example, warning labels in accordance with **16.1**) shall be provided.

When a plug/socket combination given in **5.3.2 e)** is so located that it can be kept under the immediate supervision of the person carrying out the work so as not to occur the unintended connection, 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 the following.

- Direct contact (see **6.2** and **6.4**)
- Indirect contact (see **6.3** and **6.4**)

The recommended measures for protection against electric shock selected from **JIS C 60364-4-41** are specified in **6.2**, **6.3** and **6.4**. Where these recommended measures are not practicable due to the physical restriction or operational conditions, other measures from **JIS C 60364-4-41** may be used.

6.2 Protection against direct contact

6.2.1 General

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

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

When the equipment is located in the places open to all persons including children, measures of either **6.2.2** with a minimum degree of protection against direct contact corresponding to IP4X or IPXXD (see **JIS C 0920**) or **6.2.3** shall apply.

NOTE : The degrees of protection provided by the enclosures are shown in Annex JC.

6.2.2 Protection by enclosures

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

Where the top surfaces of the enclosures are readily accessible, the minimum degree of protection against direct contact provided by the top surface 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 the enclosed electrical operating areas (see **3.19**), see **JIS C 60364-4-41** or **IEC 60439-1**.

NOTE 1 The use of a key or tool is intended to restrict access to skilled or instructed persons [see **17.2 b) 12**].

All live parts that are likely to be touched when resetting or adjusting devices intended for such operations while the equipment is still connected to the power supply shall provide the protection (degree) against direct contact to at least IP2X or IPXXB. Other live parts inside doors shall provide the protection (degree) against direct contact to at least IP1X or IPXXA.

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

This may be accomplished by interlocking the door with a disconnecter (for example, the incoming power supply disconnecter) so that the door can only be opened

when the disconnecter is open and so that the disconnecter can only be closed when the door is closed.

Exception: A special device or tool (see NOTE 2) as prescribed by the supplier can be used to disable (bypass) this interlock when the following conditions are satisfied.

- It is possible at all times while the interlock is disabled to open the disconnecter and lock the disconnecter in the OFF position, or otherwise prevent unauthorised closure of the disconnecter.
- Upon closing the door, the interlock is automatically restored (i.e. upon opening the door next, it is automatically disconnected.)
- All live parts that are likely to be touched when resetting or adjusting devices intended for such operations while the equipment is still connected to the power supply shall be protected against direct contact to at least IP2X or IPXXB. Other live parts inside the doors shall be protected against direct contact to at least IP1X or IPXXA.
- Information related to protection against electric shock is provided with the electrical equipment [see 17.2 b) 9) and 17.2 b) 12)].

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

Measures shall be provided to restrict access to live parts behind doors not directly interlocked with the disconnectors to skilled or instructed persons [See 17.2 b) 12)].

All parts that are still live after switching off the disconnecter (see 5.3.5) shall be protect against direct contact to at least IP2X or IPXXB (degree). 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).

Requirements for the marking of the warning sign given in 16.2.1 may be omitted in the following cases.

- Parts that can be live only because of connection to the interlocking circuits and that are distinguished by colour as potentially live in accordance with 13.2.4.
 - The power supply terminals of the incoming power supply disconnecter when the latter is mounted alone in a separate enclosure.
- c) Opening without the use of a key or a tool and without disconnection of live parts shall be possible only when all live parts are protected against direct contact to at least IP2X or IPXXB (degree). 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 may be caused by manual actuation of devices (for example, manual closing of contact of contactors or relays), such operation should be prevented by barriers or obstacles that requires a key of a tool for their removal.

6.2.3 Protection of live part by insulation

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 the normal use conditions.

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

6.2.4 Protection against residual voltage

Live parts having a residual voltage over 60 V after the power supply has been disconnected shall be discharged to 60 V or under within 5 s after disconnection of the power supply voltage, provided that this rate of discharge does not interfere with the proper functioning of the equipment. Parts having a stored charge of 60 μC or under are exempted from this requirement. Where this discharging rate of 5 s or under would interfere with the proper functioning of the equipment, a durable warning notice drawing attention to the hazard and stating the discharge time required before the enclosure may be opened shall be displayed at an easily visible place 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 conductor (for example, pins), the discharge time shall be 1 s or under, otherwise such conductors shall be protected against direct contact to at least IPZX or IPXXB (degree).

If neither a discharge time of 1 s nor a protection of at least IPZX or IPXXB can be achieved (for example, in the case of the removable current collectors on conductor wires, conductor bars, or slip-ring assemblies, see 12.7.4), addition of the switch capable of shutting off the stored charge or an appropriate warning means (for example, a warning notice in accordance with 16.1) shall apply.

6.2.5 Protection by barriers

For the protection by barriers, 412.2 of JIS C 60364-4-41 shall apply.

NOTE : In 412.2.1 to 412.2.4 of JIS C 60364-4-41, the protection by barriers or enclosures are specified. The specification for protection by barriers among them shall apply to 6.2.5 of this Standard.

6.2.6 Protection by placing out of reach or protection by obstacles

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

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

6.3 Protection against indirect contact

6.3.1 General

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

For each circuit or part of the electrical equipment, at least one of the following measures shall be adopted.

- Measures to prevent the occurrence of a touch voltage (given in **6.3.2**)
- Automatic disconnection of the power supply before occurrence of hazardous touch voltage (given in **6.3.3**).

NOTE 1 The risk of injury from a touch voltage depends on the magnitude of touch voltage and the exposure duration.

NOTE 2 For classes of equipment and protective provisions, see **JIS C 0365**. The definition of “Class” specified in **JIS C 0365** is shown in Annex JD.

6.3.2 Prevention of the occurrence of a touch voltage

6.3.2.1 General

The measures to prevent the occurrence of a touch voltage shall be as follows.

- Employment of Class II equipment (see Annex JD) or by equivalent insulation (according to **6.3.2.2**)
- Electrical separation (according to **6.3.2.3**)

6.3.2.2 Protection by employment of Class II equipment or by equivalent insulation

This protection 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 the execution of one or more of the following measures.

- Employment of Class II electrical devices or apparatus (double insulation, reinforced insulation or by equivalent insulation conforming to **JIS C 0365**)
- Employment of switchgear and controlgear assemblies having total insulation conforming to **IEC 60439-1**
- Employment of supplementary insulation or reinforced insulation conforming to **413.2 of JIS C 60364-4-41**

6.3.2.3 Protection by electrical separation

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

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

6.3.3 Protection by automatic disconnection of power supply

This protection measure shall be so that the conductor is disconnected by the automatic actuation of a protective device in case of an insulation fault. This breakage shall be performed within a sufficiently short time within which the touch voltage is not hazardous. The permissible breakage times applied to the TN earthing systems are shown in Annex A. The permissible breakage times applied to the TT earthing systems (mainly used in Japan) are shown in Annex JA.

For this measure, the co-ordination of the following items is necessary.

- The type of power supply and earthing system
- The impedance of each part of the protective bonding system
- The characteristics of the protective devices that detect insulation fault

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

This protective measure consists of the following two.

- Protective bonding of exposed conductive parts (see **8.2.3**)
- Any of the following **a)** to **c)**
 - a) In TN earthing systems, overcurrent protective devices for automatic disconnection of the power supply on occurrence of an insulation fault
 - b) In TT earthing systems, residual current protective devices (residual current disconnecter) for the automatic disconnection of the power supply on detection of an insulation fault from a live part to exposed conductive parts or earthing

NOTE 1 In TT earthing systems, for the installation place of the residual current disconnecter, it is considered to be necessary to agree between the user and the supplier of the electrical equipment beforehand (see Annex B). When the residual current disconnecter is not provided in the power supply circuit to the electrical equipment (outside the electrical equipment), or the residual current disconnecter provided does not satisfy the requirements given in Annex JA, it becomes necessary to provide the ground fault interrupter inside the electrical equipment. When two or more residual current disconnecters exist in a power supply system, the coordination of characteristics (sensitivity current, interrupting time, etc.) of each protective device is needed.

NOTE 2 When the occurrence of a touch voltage can be prevented by adopting the measures in **6.3.2**, the residual current disconnecter may or may not be used (see **6.3.1**).

- c) In IT earthing systems, insulation monitoring devices or residual current protective devices for promoting automatic disconnection. Except where a protective device is provided to break the power supply in case of the first ground 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 earthing. This insulation monitoring device shall initiate an audible and/or visual signal which shall continue as long as the fault persists.

NOTE 3 In large machine, an employment of means to find the ground fault point can facilitate maintenance.

Where automatic disconnection of **a)** is provided, but disconnection within the time given in clause **A.1** cannot be assured, supplementary bonding satisfying the requirements of clause **A.3** shall be provided.

6.4 Protection by use of PELV

NOTE : PELV (Protective Extra-Low Voltage) refers to a voltage which does not exceed ELV (Extra-Low Voltage) in a steady state and a single fault condition (except the ground fault failure of other circuit). The PELV circuit is earthed. ELV circuit which is not earthed is called SELV. Although the voltage value of ELV is under 50 V a.c. and under 120 V d.c. for the definition of **IEC 60449**, according to the application standards, the required value of PELV may be different from this. The severer value than this is given in **6.4.1** of this Standard.

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 circuit shall satisfy all of the following **a)** to **e)** conditions.

- a) The nominal voltage shall not exceed the following values.
 - 25 V a.c. (r.m.s.) or 60 V d.c. (ripple-free) when the equipment is normally used in dry places and when large area contact of live parts with the human body is not expected
 - 6 V a.c. (r.m.s.) or 15 V d.c. (ripple-free) in all other cases

NOTE : Ripple-free herein is defined for a sinusoidal ripple voltage as a ripple content of not exceeding 10 % r.m.s.

- b) One side of the circuit or one point of the power 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 satisfy the required condition 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 means 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 capable of entering to the socket-outlets of other voltage systems.
 - 2) Socket-outlets shall not admit plugs of other voltage systems.

6.4.2 Power supply for PELV

The power supply for PELV shall be one of the following.

- A safety isolating transformer conforming to **IEC 61558-1** and **IEC 61558-2-6**
- A power supply providing a degree of safety equivalent to that of the safety isolating transformer (for example, a motor generator with winding providing equivalent isolation)

- An electrochemical power supply (for example, a battery) or another power supply independent of a higher voltage circuit (for example, a diesel-driven generator)
- An electronic power supply conforming to appropriate standards specifying measures to be taken to ensure that the voltage at the outgoing terminals can not exceed the values given in **6.4.1** even in the case of an internal fault

7 Protection of equipment

NOTE : The “equipment” given in clause **7** mainly means the single unit (a transformer, motor, conductor, etc.) (see **3.21**).

7.1 General

In clause **7**, the measures to be taken to protect equipment against the following effects are specified.

- Overcurrent due to a short-circuit accident
- Overload and/or loss of cooling of motors
- Abnormal temperature
- Loss of power supply voltage or voltage reduction
- Overspeed of machines and machine elements
- Ground fault current or residual current
- Incorrect phase sequence
- Overvoltage due to lightning and switching surges

7.2 Overcurrent protection

7.2.1 General

Overcurrent protection shall be provided where that the circuit current in a machine (equipment) may exceed either the rating of any component or the permissible current-carrying capacity of conductors, whichever is the smaller. The ratings or settings to be selected shall be given in **7.2.10**.

7.2.2 Power supply conductor

NOTE : The power supply conductor given in **7.2.2** shall be the power supply wire generally not included in the construction of electrical equipment (prepared by the user of electrical equipment) outward the input terminal of the electrical equipment.

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

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

7.2.3 Power circuit

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

The following conductors shall not be disconnected without disconnecting all associated live conductors.

- The neutral conductor of a.c. power supply circuits
- The earthing conductor of d.c. power supply circuits
- Conductors of d.c. power supply bonded to exposed conductive parts of mobile machines

Where the cross-sectional area of the neutral conductor is at least equivalent to that of the phase conductors, it is not necessary to provide a overcurrent detector nor a disconnecter for that neutral conductor. For a neutral conductor with a cross-sectional area smaller than that of the associated phase conductors, the overcurrent protection specified in **524** of **JIS C 60364-5-52** shall apply.

In IT earthing systems, the neutral conductor should not be used. When the neutral conductor is used, however, the measures specified in **431.2.2** of **JIS C 60364-4-43** shall apply.

7.2.4 Control circuits

Conductors of control circuits directly connected to the incoming power supply and of circuits supplying control circuit transformers shall be protected against the overcurrent in accordance with **7.2.3**.

Conductors of control circuits supplied by a control circuit transformer or d.c. power supply shall be protected against the overcurrent according to the following (see also **9.4.3.1**).

- An overcurrent protective equipment shall be inserted into the switched conductor in control circuits connected to the protective bonding circuit.
- The following shall apply to control circuits not connected to the protective bonding circuit.
 - When conductors of same cross-sectional area are used in all control circuits, an overcurrent protective device shall be inserted into the switched conductor.
 - When conductors of different cross-sectional areas are used in different sub-circuits, an overcurrent protective device shall be inserted into both switched and common conductors of each sub-circuit.

7.2.5 Socket-outlets and conductors for feeding them

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-outlet.

7.2.6 Lighting circuits

All unearthed conductors of power supply circuits for lighting shall be protected against the effects of short-circuits by the overcurrent protective devices only for the power supply circuits for lighting separate from those protecting other circuits.

7.2.7 Transformers

Transformers shall be protected against overcurrent in accordance with the manufacturer's instructions. Such protection for transformer shall satisfy the following. (see also 7.2.10).

- Nuisance tripping due to transformer inrush currents shall be avoided.
- A winding temperature rise in excess of the permissible value for the insulation class of transformer when it is subjected to the effects of a short-circuit at its secondary terminals shall be avoided.

The type and set value of actuating current (trip current of circuit disconnecter, fusing current of fuse) of the overcurrent protective device should be in accordance with the recommendations of the transformer supplier.

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 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 all conductors shall be at least equal to that of the load.
- The part of conductor between the point of reduction of current-carrying capacity and the position of the overcurrent protective device shall not exceed 3 m.
- The conductor shall be installed in such a manner as to reduce the possibility of a short-circuit, for example, protected by an enclosure or duct.

7.2.9 Overcurrent protective devices

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

A lower breaking capacity is permissible where another overcurrent protective device, for example, the overcurrent protective device for the power supply conductors (see 7.2.2) having the necessary breaking capacity is set on the power supply side of the electrical equipment. In this case, the characteristics of two overcurrent protective devices shall be co-ordinated so that the let-through energy (I^2t) of 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 thereby (see Annex A of JIS C 8201-2-1).

NOTE : The use of such a co-ordination of overcurrent protective devices can result in the correct operation of both overcurrent protective devices.

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

7.2.10 Rating and setting value of operating current of overcurrent protective device

The rated current of fuses or the setting current of other overcurrent protective devices shall be made as low as possible, but adequate for the anticipated overcurrent

(for example, during starting of motors or energizing of transformers). When selecting these protective devices, consideration shall be given to the protection of switching devices against damage due to the overcurrents (for example, welding of contacts).

The rated current or set value of operating current of an overcurrent protective device is determined by the permissible current of the conductors to be protected and the maximum permissible breakage time t . The permissible current of the conductor can be determined in accordance with **12.4** and **D.2** and the maximum permissible breakage time t in accordance with **D.3**. In this case, the needs of co-ordination with other electrical devices in the protected circuit shall be considered.

7.3 Protection against overheating of motors

7.3.1 General

Protection against overheating shall be provided for each motor rated at over 0.5 kW.

Exception: In applications where an automatic stop of the motor operation is unacceptable (for example, fire pumps), the means of detection shall give a warning signal to which the operator can respond.

Protection of motors against overheating can be achieved by the following.

- Overload protection (given in **7.3.2**)

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

- Over-temperature protection (given in **7.3.3**)

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

or

- Current-limiting protection (given in **7.3.4**)

Automatic restarting of any motor after the actuation of over-temperature protective function shall be prevented where this may 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, the overload in each live conductor except for the neutral conductor shall be detected. However, where the overload detector for motor is not used for cable overload protection, the number of overload detectors may be reduced upon the request of the user by installing the overload detector limited to part of live conductors (see also **D.2**). For single-phase or d.c. power supply motors, detection in only one unearthed live conductor is permitted.

Where the overload protection is achieved by the switching device, it shall break all live conductors at overload. The breakage of the neutral conductor is not necessary for overload protection.

For motors with special duty ratings required to start or to brake frequently (for example, motors for rapid traverse, locking, rapid reversal, or sensitive drilling), it may be difficult to provide overload protection with a time constant comparable with that