

JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS B 9960-33 : 2012

(IEC 60204-33 : 2009)

(JMF)

**Safety of machinery—Electrical
equipment of machines—Part 33:
Requirements for semiconductor
fabrication equipment**

ICS 13.110;25.040.30;29.020

Reference number : **JIS B 9960-33 : 2012 (E)**

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Date of Establishment: 2012-05-21

Date of Public Notice in Official Gazette: 2012-05-21

Investigated by: Japanese Industrial Standards Committee
Standards Board

Technical Committee on Industrial Machinery

JIS B 9960-33:2012, First English edition published in 2013-01

Translated and published by: Japanese Standards Association
4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN

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Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee according to the proposal for establishment 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.

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JIS B 9960 series consists of the following 5 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

Part 33: Requirements for semiconductor fabrication equipment

Safety of machinery—Electrical equipment of machines—Part 33: Requirements for semiconductor fabrication equipment

Introduction

This Japanese Industrial Standard has been prepared based on the first edition of **IEC 60204-33** published in 2009 without any modifications of technical contents.

The portions with continuous sidelines or dotted underlines are the matters not given in the corresponding International Standard.

This Standard reflects the unique needs of electrical safety within the semiconductor manufacturing environment. This includes the specialized cleanroom environment in which semiconductors are fabricated as well as the specialized nature of the semiconductor fabrication equipment itself. This Standard ensures a level of safety consistent with **JIS B 9960-1** while still permitting the flexibility needed in the design and operation of semiconductor fabrication equipment. It has been drafted to satisfy the electrical safety needs of the semiconductor industry.

This Standard is not intended to address those functional aspects of semiconductor fabrication equipment that do not relate directly to safety.

NOTE : In this Standard, values of a.c. voltage (V) means effective values (r.m.s.) unless otherwise specified.

1 Scope

This Standard applies to electrical and electronic equipment (see definition **3.20**) associated with semiconductor fabrication equipment (see definition **3.28**) for the manufacture, measurement, assembly, and test of semiconductors.

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

NOTE 2 In the context of this Standard, the term person refers to any individual and includes those persons who are assigned and instructed by the user or his agent(s) in the installation, use, and care of the fabrication equipment in question.

The electrical equipment covered by this Standard commences at the point of connection of the supply to the electrical equipment (see **5.1**), and includes proper instruction for its safe installation • operation.

NOTE 3 For the requirements for the electrical supply installation in buildings, see **JIS C 60364** series.

This Standard is applicable to the electrical equipment or parts of the electrical equipment that operate with nominal supply voltages not exceeding 1 000 V for alternating current (a.c.) and not exceeding 1 500 V for direct current (d.c.), and with nominal supply frequencies not exceeding 200 Hz. For higher voltages or frequencies, special requirements may be needed.

NOTE 4 Electrical equipment within which derived voltages exceed these supply voltage limits is within the scope of this Standard.

Included are requirements for protective measures against electrical safety hazards as well as electrical interlock circuits that protect against non-electrical hazards. However, it does not cover all the requirements that are needed or required by other standards or regulations in order to safeguard persons from hazards other than electrical hazards (e.g. chemical hazards, mechanical hazards, radiation hazards). Each type of machine has unique requirements to be accommodated to provide adequate safety.

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

- use, process, or produce potentially explosive material;
- are used in potentially explosive and/or flammable atmospheres;
- have special risks when producing or using certain materials;
- are hoisting machines (which are covered by **JIS B 9960-32**).

This Standard does not include specifications for performance or functional characteristics of the fabrication equipment.

This Standard does not deal with the possible effects on human health that can result from emissions (for example, EMFs, noise) from the fabrication equipment.

This Standard does not specify requirements for electromagnetic compatibility (EMC).

NOTE 5 The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

IEC 60204-33:2009 *Safety of machinery—Electrical equipment of machines—Part 33: Requirements for semiconductor fabrication equipment* (IDT)

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 21-1**.

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 be applied and the revisions (including amendments) made thereafter shall not be applied. For those without the indication of the year, the most recent edition (including amendments) shall be applied.

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

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

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

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

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

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

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

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

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

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

JIS B 9712 *Safety of machinery—Two-hand control devices—Functional aspects and design principles*

NOTE : Corresponding International Standard: ISO 13851 *Safety of machinery—Two-hand control devices—Functional aspects and design principles* (IDT)

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

NOTE : Corresponding International Standard: IEC 62061 *Safety of machinery—Functional safety of safety-related electrical, electronic and programmable electronic control systems* (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 0446 *Identification of conductors by colours or numerals*

NOTE : Corresponding International Standard: IEC 60446 *Basic and safety principles for man-machine interface, marking and identification—Identification of conductors by colours or alphanumerics* (MOD)

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 0617 (series) *Graphical symbols for diagrams*

NOTE : Corresponding International Standard: IEC 60617 (all parts) *Graphical symbols for diagrams* (MOD)

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

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

JIS C 0922 *Protection of persons and equipment by enclosures for electrical apparatus—Probes for verification*

NOTE : Corresponding International Standard: IEC 61032 *Protection of persons and equipment by enclosures—Probes for verification* (IDT)

JIS C 1010-1 *Safety requirements for electrical equipment for measurement, control, and laboratory use—Part 1: General requirements*

NOTE : Corresponding International Standard: IEC 61010-1 *Safety requirements for electrical equipment for measurement, control, and laboratory use—Part 1: General requirements* (MOD)

JIS C 6950-1 *Information technology equipment—Safety—Part 1: General requirements*

NOTE : Corresponding International Standard: IEC 60950-1 *Information technology equipment—Safety—Part 1: General requirements* (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 60364-4-41 *Low-voltage electrical installations—Part 4-41: Protection for safety—Protection against electric shock*

NOTE : Corresponding International Standard: IEC 60364-4-41 *Low-voltage electrical installations—Part 4-41: Protection for safety—Protection against electric shock* (IDT)

JIS C 60364-4-43 *Low-voltage electrical installations—Part 4-43: Protection for safety—Protection against overcurrent*

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

JIS C 60364-6 *Low-voltage electrical installations—Part 6: Verification*

NOTE : Corresponding International Standard: IEC 60364-6 *Low-voltage electrical installations—Part 6: Verification* (IDT)

JIS C 60695-11-10 *Fire hazard testing—Part 11-10: Test flames—50 W horizontal and vertical flame test methods*

NOTE : Corresponding International Standard: IEC 60695-11-10 *Fire hazard testing—Part 11-10: Test flames—50 W horizontal and vertical flame test methods* and Amendment 1 (IDT)

JIS C 61558-1 *Safety of power transformers, power supplies, reactors and similar products—Part 1: General requirements and tests*

NOTE : Corresponding International Standard: IEC 61558-1 *Safety of power transformers, power supplies, reactors and similar products—Part 1: General requirements and tests* (MOD)

JIS C 61558-2-6 *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V—Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers*

NOTE : Corresponding International Standard: IEC 61558-2-6 *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V—Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers* (MOD)

IEC 60034-11:2004 *Rotating electrical machines—Part 11: Thermal protection*

IEC 60038 *IEC standard voltages*

IEC 60072 (all parts) *Dimensions and output series for rotating electrical machines*

IEC 60417 *Graphical symbols for use on equipment*

IEC 61508-3 *Functional safety of electrical/electronic/programmable electronic safety-related systems—Part 3: Software requirements*

IEC 61557-3:2007 *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c.—Equipment for testing, measuring or monitoring of protective measures—Part 3: Loop impedance*

IEC 61800-5-1:2007 *Adjustable speed electrical power drive systems—Part 5-1: Safety requirements—Electrical, thermal and energy*

3 Terms and definitions

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

3.1 actuator

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

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

NOTE 2 There are some actuating means that do not require an external actuating force but only an action.

NOTE 3 See also 3.43.

3.2 ambient temperature

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

[IEV 826-01-04]¹⁾

Note ¹⁾ **IEV**: International Electrotechnical Vocabulary is specified in **IEC 60050**. **IEV 826-01-04** means **01-04** of **IEC 60050-826** (the same shall apply hereinafter).

3.3 appliance coupler

means enabling the connection and disconnection at will, of a cord to an appliance or other equipment and consisting of a connector and an appliance inlet

NOTE 1 An appliance inlet integrated in an appliance or equipment is an appliance inlet the shroud and base of which is formed by the housing of the appliance or equipment.

NOTE 2 An appliance inlet incorporated in an appliance or an equipment is a separate appliance inlet built-in or fixed to an appliance or equipment.

3.4 automatic disconnection

interruption of one or more of the line conductors by the automatic operation of a protective device in case of a fault

3.5 barrier

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

[IEV 826-03-13]

3.6 basic insulation

insulation of hazardous-live-parts which provides basic protection (protection against direct contact)

[IEV 195-06-06]

3.7 cable tray

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

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

[IEV 826-06-08]

3.8 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

[IEV 826-06-04]

3.9 concurrent actuation

acting in conjunction; used to describe a situation wherein two or more control devices exist in an actuated condition at the same time (but not necessarily synchronously)

3.10 conduit

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

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

[IEV 826-06-03]

3.11 control device

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

3.12 controlgear

switching devices and their combination with associated control, measuring, protective, and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures, and supporting structures, intended for the control of electrical energy consuming equipment

[IEV 441-11-03, modified]

3.13 controlled stop

stopping of machine motion with electrical power to the machine actuators maintained during the stopping process (until it comes to a complete stop)

3.14 class II equipment

equipment with

- basic insulation as provision for basic protection²⁾, and supplementary insulation^{4), 5)} as provision for fault protection³⁾

or in which

- basic and fault protection are provided by reinforced insulation⁶⁾

[JIS C 0365, 7.3]

Notes ²⁾ Basic protection has protective function against direct contact.

³⁾ Fault protection has protective function against indirect contact. The term fault here means mainly insulation failure (electric leakage).

⁴⁾ Supplementary insulation is defined in **3.70**. (In this Standard and **JIS C 0365**, supplementary insulation is expressed in Japanese “HOZYO ZETUEN”.)

⁵⁾ In **JIS C 60664-1**, supplementary insulation is expressed in Japanese “HUKA ZETUEN”.

⁶⁾ Reinforced insulation is defined in **3.59**.

3.15 danger zone

in the case of high voltage installations, systems, and equipment, area limited by the minimum clearance around hazardous-live-parts without complete protection against direct contact

NOTE 1 Entering the danger zone is considered to be the same as touching hazardous-live-parts.

[JIS C 0365, 3.35, modified]

NOTE 2 Definition **3.15** represents danger zone relevant to electrical shock and is different from the definition specified in **JIS B 9700-1, 3.10** (hazard zone, danger zone).

NOTE 3 In this Standard, the term danger zone is only used in NOTE to **3.16** below. It does not refer to parts where an incoming supply voltage (e.g. 200 V) is exposed.

NOTE 4 Fabrication equipment includes such that generates voltage far higher than the incoming supply voltage (e.g. 200 V) in itself to use for the semiconductor fabrication. Above mentioned "hazardous-live-parts of high voltage installations, systems, and equipment" refer to high voltage parts generated in the equipment. It does not mean that incoming supply voltage is high (e.g. 1 000 V a.c. or over).

3.16 direct contact

contact of persons with live parts

NOTE : For high-voltage installations, systems, and equipment, entering the danger zone (see definition **3.15**) is considered to be the same as touching hazardous live parts.

3.17 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)

[JIS C 8201-5-1, K.2.2]

3.18 double insulation

insulation comprising both basic insulation and supplementary insulation

3.19 duct

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

NOTE : Conduits (see **3.10**), cable trunking systems (see **3.8**) and underfloor channels are types of duct.

3.20 electrical equipment

material, fittings, devices, components, appliances, fixtures, apparatus, and the like used as part of, or in connection with the use of electricity by semiconductor fabrication equipment

Also total of integrated systems and assemblies thereof.

NOTE : See also **3.28**.

3.21 emergency stop device

manually actuated control device used to initiate an emergency stop function

[JIS B 9703, 3.2]

3.22 EMO, emergency off

function which, when activated, will place the fabrication equipment into a safe shut-down condition, without generating any additional hazards

3.23 enclosed electrical equipment area

room or location for electrical equipment (see definition **3.20**) to which access is intended to be restricted to skilled or instructed persons by the opening of a door or the removal of a barrier by the use of a key or tool and which is clearly marked by appropriate warning signs

3.24 enclosure

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

[IEV 826-03-12]

NOTE : The definition taken from the existing IEV needs the following explanations within the scope of this Standard:

- a) Enclosures provide protection of persons against access to hazardous parts.
- b) Barriers, shaped openings, or any other means suitable to prevent or limit the penetration of the specified test probes, whether attached to the enclosure or formed by the enclosed equipment, are considered as part of the enclosure, except where they can be removed without the use of a key or tool.
- c) An enclosure may be:
 - a cabinet or box, either mounted on the machine or separate from the machine;
 - a compartment consisting of an enclosed space within the machine structure.

3.25 equipotential bonding

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

[IEV 195-01-10]

3.26 exposed conductive part

conductive part of electrical equipment, which can be touched and which is not live under normal operating conditions, but which can become live under fault conditions

[IEV 826-12-10, modified]

3.27 extraneous conductive part⁷⁾

conductive part, for example of the fabrication equipment, not forming part of the electrical equipment

Note ⁷⁾ In **JIS C 0365**, “extraneous conductive part” is expressed in Japanese “KEITÔGAI DÔDENSEI BUBUN”.

3.28 fabrication equipment

machinery, associated electrical equipment, apparatus, process modules or devices used to manufacture, measure, assemble and test semiconductor products but not including any product (e.g., substrates, semiconductors)

NOTE : See also **3.20**.

3.29 failure

termination of the ability of an item⁸⁾ to perform a required function

NOTE 1 After failure the item has a fault.

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

[IEV 191-04-01, modified]

NOTE 3 In practice, the terms fault and failure are often incorrectly used synonymously.

Note ⁸⁾ An item means any part, component, device, functional unit, equipment, subsystem or system that can be subject to dependability individually or items collectively mean for them. An item may consist of hardware, software or both. (See **JIS Z 8115**, clause **G1**.)

3.30 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 (e.g. power disruption)

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” can mean insulation fault or earth fault. In **IEC 60204-33**, the term fault is used in this sense most frequently.

3.31 functional bonding

equipotential bonding necessary for proper functioning of electrical equipment

3.32 harm

physical injury or damage to health

[JIS B 9700-1, 3.5]

3.33 hazard

potential source of physical injury or damage to health

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

NOTE 2 The hazard envisaged in this definition:

- either is 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);
- or can appear unexpectedly (for example, explosion, crushing hazard as a consequence of an unintended/unexpected start-up, ejection as a consequence of a breakage, fall as a consequence of acceleration/deceleration).

[JIS B 9700-1, 3.6, modified]

3.34 hazardous electrical power

power levels equal to or greater than 240 VA

NOTE : “Hazard” in this term means not only hazard of electric shock but also that of mechanical or thermal energy converted from electric energy. It is dangerous to be shocked by hazardous voltage (see **3.35** and **3.37**), even if 240 VA or less; conversely, great current is hazardous as energy even if the voltage does not exceed the hazardous voltage. In **1.2.8.10** of **JIS C 6950-1**, available power level of 240 VA or more, having a duration of 60 s or more is defined as hazardous energy level.

3.35 hazardous-live-part

live part which under certain conditions, can give a harmful electric shock

[IEV 195-06-05]

NOTE : For the purposes of this Standard voltages greater than 30 V r.m.s., 42.4 V peak, or 60 V d.c. are considered to have the possibility of a harmful electric shock.

3.36 hazardous situation

circumstance in which a person is exposed to at least one hazard

The exposure can immediately or over a period of time result in harm.

[JIS B 9700-1, 3.9]

3.37 hazardous voltage

voltage greater than 30 V r.m.s., 42.4 V peak, or 60 V d.c.

3.38 indirect contact

contact of persons with exposed conductive parts which have become live under fault conditions

[IEV 826-12-04, modified]

3.39 inductive power supply system

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

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

3.40 (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, modified]

3.41 interlock

arrangement of devices operating together to:

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

3.42 live part

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

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

[IEV 826-03-01]

3.43 machine actuator

power mechanism used to effect motion within the fabrication equipment

NOTE : See also 3.1.

3.44 machinery, machine

assembly of linked parts or components, at least one of which moves, with the appropriate machine actuators, control and power circuits, joined together for a specific application, in particular for the processing, treatment, moving or packaging of a material

The term “machinery” also covers an assembly of machines which, in order to achieve the same end, are arranged and controlled so that they function as an integral whole

[JIS B 9700-1, 3.1, modified]

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

3.45 maintenance

activities intended to keep fabrication equipment in proper working order

NOTE : See also 3.60.

3.46 marking

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

3.47 neutral conductor, N

in a star-connected three-phase system, conductor connected to the common point and capable of contributing to the transmission of electrical energy and in a single-phase system, a conductor connected to the side that is commonly at the same potential as the protective earth

[IEV 826-01-03, modified]

NOTE : The neutral point is only defined for a.c. systems.

3.48 obstacle

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

[IEV 826-03-14]

3.49 operator

person who interacts with the fabrication equipment in order for it to perform its intended function

NOTE 1 Operator functions are distinct from maintenance and repair functions.

NOTE 2 Performance of operator functions does not require the knowledge or ability of a skilled or instructed person.

3.50 overcurrent

current exceeding the rated value

NOTE : For conductors, the rated value is the current-carrying capacity.

[IEV 826-05-06, modified]

3.51 overload (of a circuit)

time/current relationship in a circuit which is in excess of the rated full load of the circuit when the circuit is not under a fault condition

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

3.52 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 include:

- connectors which fulfil the requirements of **IEC 61984**;
- a plug and socket-outlet, a cable coupler, or an appliance coupler in accordance with **JIS C 8285**;
- a plug and socket-outlet in accordance with **JIS C 8282-1** or an appliance coupler in accordance with **JIS C 8283-1**.

3.53 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.

3.54 protective bonding circuit

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

3.55 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 826-04-05, modified]

NOTE : “some measures” include for example protection by automatic disconnection of supply.

3.56 protective interlock circuit

type of safety circuit, the purpose of which is to prevent the operation of hazardous functions under specified conditions, and which starts at the point where the safety-related signals are generated and ends at the components used to eliminate the hazard or reduce the risk

3.57 readily accessible

capable of being reached without requiring the use of tools, keys, portable ladders or platforms, climbing over or removing obstacles or barriers

3.58 reference designation

distinctive code which serves to identify unambiguously an item in the documentation and on the electrical equipment

NOTE : The Japanese term “RYAKUGÔ” in this Standard corresponds to “SANSYÔ SITEI” in **JIS C 0452-1** and **JIS C 0452-2**.

3.59 reinforced insulation

insulation of hazardous-live-parts which provides a degree of protection against electric shock equivalent to double insulation

NOTE : Reinforced insulation may comprise several layers which cannot be tested singly as basic insulation or supplementary insulation.

[IEV 195-06-09]

3.60 repair

activities intended to return to proper working order fabrication equipment that has failed (see also **3.45**)

3.61 residual current device, RCD

mechanical switching device designed to make, carry and break currents under normal conditions and to cause the opening of the contacts when the residual current attains a given value under specified conditions

NOTE 1 A residual current device can be a combination of various separate elements designed to detect and evaluate the residual current and to make and break current.

NOTE 2 A GFCI (ground-fault circuit interrupter) is a specific kind of RCD.

[IEV 442-05-02, modified]

3.62 risk

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

[JIS B 9700-1, 3.11, modified]

3.63 safeguard

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

[JIS B 9700-1, 3.24, modified]

3.64 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

[JIS B 9700-1, 3.20]

NOTE : Protective interlocks are examples of safeguarding.

3.65 safety circuit

circuit that carries out a safety function that is intended to maintain the safe condition of the fabrication equipment or prevent an increase of the risks under single fault conditions

NOTE : Safety circuits include protective interlock circuits and emergency off (EMO) circuits.

3.66 servicing level

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

3.67 short-circuit current

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

[IEV 441-11-07]

3.68 short-circuit rating of the electrical equipment

maximum input current from the supply, resulting from a short-circuit fault, that the equipment can withstand under defined conditions

NOTE 1 This necessitates adequate co-ordination of protective devices within the equipment such that the short-circuit ratings of all the overcurrent protective devices in the equipment are at least equal to the prospective fault current at their points of connection within the equipment and adequate protection is provided by those devices.

NOTE 2 Where multiple input supplies are used for the electrical equipment (fabrication equipment) short-circuit current ratings are determined for each respective supply.

3.69 (electrically) skilled person

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

[IEV 826-09-01, modified]

3.70 supplementary insulation

independent insulation applied in addition to basic insulation, for fault protection (protection against indirect contact)

[IEV 195-06-08]

3.71 supplier

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

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

3.72 switching device

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

[IEV 441-14-01, modified]

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

3.73 touch voltage

voltage between conductive parts when touched simultaneously by a person

[IEV 195-05-11, modified]

3.74 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 or hydraulic brakes.

3.75 UPS, uninterruptible power supply

power source that is capable of supply power to the electrical equipment after power from the facilities has been discontinued

3.76 user

entity who utilizes the fabrication equipment and its associated electrical equipment

4 General requirements

4.1 General considerations

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 fabrication equipment. This will enable the determination of adequate risk reduction, and the necessary protective measures for persons who can be exposed to those hazards, while still maintaining an acceptable level of performance of the fabrication 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 associated with those circuits) resulting in the malfunctioning of the fabrication equipment that can increase risk;
- disturbances or disruptions in power sources as well as failures or faults in the electrical equipment resulting in the malfunctioning of the fabrication equipment that can increase risk;
- loss of continuity of circuits that depend upon sliding or rolling contacts, resulting in a failure of a safety function;
- electrical disturbances (for example, electromagnetic, electrostatic either from outside the electrical equipment or internally generated, resulting in the malfunctioning of the fabrication equipment that can increase risk);
- release of stored energy (either electrical or mechanical) resulting in, for example, electric shock, unexpected movement that can cause injury;
- surface temperatures that can cause injury.

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

During the design and development process, hazards and the risks arising from them shall be identified. 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 risk can be necessary.

4.2 Selection of electrical equipment

Electrical components and devices that are used as part of a safety related system and those that handle hazardous voltage or hazardous electrical power shall be suitable for their intended use, be applied in accordance with their supplier's instructions; and

- conform to relevant **IEC** standards where such exist;

- as an alternative, conform to a Japanese Industrial Standard and/or meet construction and test requirements of this Standard as is appropriate to the application.

4.3 Electrical supply

4.3.1 General

The electrical equipment shall operate correctly when connected to its specified electrical supply. The specifications for the supply shall include the following where appropriate:

- a.c. source: nominal supply voltage with plus and minus tolerances;
- d.c. source: nominal supply voltage with plus and minus tolerances.

The term “correct operation” in this context does not consider the quality of the fabricated product.

Interruptions in the facilities electrical supply shall not result in hazardous conditions.

4.4 Physical environment and operating conditions

4.4.1 General

The electrical equipment shall be suitable for use in the physical environment and operating conditions specified by the manufacturer of the fabrication equipment including the following environmental parameters:

- ambient air temperature range;
- limitations on altitude of installation;
- humidity of operating installation;
- electromagnetic environment.

NOTE 1 The generic EMC standards **JIS C 61000-6-1** or **JIS C 61000-6-2** and **IEC 61000-6-3** or **IEC 61000-6-4** give general EMC emission and immunity limits.

NOTE 2 **IEC/TR 61000-5-2** gives guidelines for earthing and cabling of electrical and electronic systems aimed at ensuring EMC. If specific product standards or product family EMC standards exist (for example, **JIS B 9704-1**, **JIS C 4421**, **JIS C 8201-5-2**, **JIS C 1806-1**) they take precedence over generic standards.

4.4.2 Contaminants

Electrical equipment shall be adequately protected against the ingress of solid bodies and liquids likely to be present in the environment in which the electrical equipment is intended to be used. Electrical equipment shall be adequately protected against or resistant to degradation resulting from foreseeable chemical exposures.

4.4.3 Ionizing and non-ionizing radiation

When electrical equipment can be subject to radiation (e.g. microwave, ultraviolet, lasers, X-rays), additional measures shall be taken to avoid failures of the electrical equipment that can result in a hazardous situation.

4.4.4 Vibration, shock, and bump

Effects of vibration, shock and bump (including those generated by the fabrication equipment and those created by the physical environment) that can result in a hazardous situation shall be avoided by the selection of suitable electrical equipment, by mounting it away from the source of disturbance, or by provision of anti-vibration mountings.

4.5 Transportation and storage

Unless the manufacturer specifies different temperature and humidity ranges, the equipment shall withstand temperatures from -25°C to $+55^{\circ}\text{C}$ and for short periods not exceeding 24 h, $+70^{\circ}\text{C}$, and relative humidity from 10 % to 90 %.

NOTE : Electrical equipment susceptible to damage at low temperatures includes PVC insulated cables.

Suitable means should be provided to prevent damage from humidity, vibration, and shock.

4.6 Provisions for handling

Heavy and bulky electrical equipment shall be provided with suitable means for handling, for example by mechanical handling equipment.

4.7 Installation

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

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

5.1 Incoming supply conductor terminations

5.1.1 General

It is recommended that, where practicable, there should be a single point of connection for the incoming electrical supply. Where another supply is necessary for certain parts of the electrical equipment (for example, electronic equipment that operates at a different voltage), that supply should be derived, as far as is practicable, from devices (for example, transformers, converters) forming part of the electrical equipment. For large complex fabrication equipment comprising a number of widely-spaced subsystems working together in a co-ordinated manner, there can be a need for more than one incoming supply depending upon the site supply arrangements (see **5.3.1**).

5.1.2 Termination of the supply conductors

Unless the electrical equipment is cord and plug connected [see **5.3.2 d**)], it is recommended that the supply conductors be terminated at the supply disconnecting device.

5.1.3 Neutral conductor

Where a neutral conductor is used it shall be clearly indicated in the technical documentation of the fabrication equipment, such as in the installation diagram and in the

circuit diagram, and a separate insulated terminal, labelled N or “Neutral” in accordance with **16.1**, shall be provided for the neutral conductor.

There shall be no connection between the neutral conductor and the protective bonding circuit nor shall a combined PEN terminal be provided.

Exception: A connection may be made between the neutral terminal and the PE terminal at the point of the connection of the power supply for TN-C systems⁹⁾.

Note ⁹⁾ TN-C system is that in which neutral and protective conductor functions are combined in a single PEN conductor through the TN system. TT system but not TN system is used in the commercial power supply in Japan. Earthing in the distribution systems is illustrated in Annex E with specific wire connections.

5.1.4 Terminal identification

All terminals for the incoming supply connection shall be clearly identified with one of the following:

- “U”, “V”, and “W”
- “L1”, “L2”, and “L3”

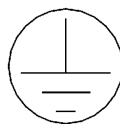
For the identification of the external protective conductor terminal, see **5.2**.

5.2 Terminal for connection to the external protective earthing system

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

NOTE : This is intended to facilitate the provision of an external protective earthing system or external protective conductor in association with the incoming supply conductors.

The terminal shall be of such a size as to enable the connection of an external protective copper conductor with a cross-sectional area in accordance with tables C.1 to C.5. At each incoming supply point, the terminal for connection of the external protective earthing system or the external protective conductor shall be marked or labelled with the letters PE and/or the symbol **IEC 60417-5019** (see **JIS C 0445**):



5.3 Supply disconnecting (isolating) device

5.3.1 General

A supply disconnecting device shall be provided:

- for each incoming source of supply to the fabrication equipment;

NOTE : The incoming supply can be connected directly to the machine or via a feeder system. Feeder systems can include conductor wires, conductor bars, slip-ring assemblies, flexible cable systems (reeled, festooned) or inductive power supply systems.

— for the output of each UPS, in accordance with **5.3.7**.

Each supply disconnecting device shall remove electrical power from the load side of the disconnecting device when it is opened (for example, for work on the fabrication equipment, including the electrical equipment).

Where two or more supply disconnecting devices are provided, interlocks shall be provided as necessary to prevent a hazardous situation.

When two or more supply disconnecting devices are present each shall be provided with marking such as

**“WARNING: Risk of Electric Shock or Burn.
Disconnect all [number of feed locations] sources of
electrical supply prior to maintenance or repair”**

5.3.2 Type

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

- a) a switch-disconnector, with or without fuses, utilization category AC-23B or DC-23B (see **JIS C 8201-3**);
- b) a disconnector, with or without fuses, that has an auxiliary contact that in all cases causes switching devices to break the load circuit before the opening of the main contacts of the disconnector;
- c) a circuit-breaker suitable for isolation;
- d) a plug/socket combination under the following conditions;
 - the plug/socket combination shall be connected so that the part connected to the incoming supply is protected to at least IP2X or IPXXB, and either
 - the total power rating shall be less than 3 kW (the rated current should not exceed 16 A);
 - it shall not be possible to connect or disconnect a plug/socket combination without adequate breaking capacity, during load conditions;
 - where a plug/socket combination with breaking capacity is used, it shall have a breaking capacity of at least the rated current of the machine at rated voltage. Where a plug/socket combination is used for disconnection under overload (e.g. locked rotor), the rating should be at least locked rotor current. In addition, the electrical equipment shall have a device for switching the machine on and off.

NOTE : For switch-disconnectors and disconnectors, see **JIS C 8201-3**. For circuit-breakers suitable for isolation, see **JIS C 8201-2-1**.

5.3.3 Requirements

When the supply disconnecting device is one of the first three types specified in **a)** to **c)** of **5.3.2** (i.e. a switch-disconnector, a disconnector used in combination with switching devices, or a circuit-breaker), it shall fulfil all of the following requirements:

- a) isolate the electrical equipment from the supply and have one OFF (isolated) and one ON position marked with “○” and “I” (symbols **IEC 60417-5008** and **IEC 60417-5007**, see **10.2.2**); a ‘tripped’ position is also permitted in the case of circuit-breakers;
- b) have a visible contact gap or a position indicator which cannot indicate OFF (isolated) until all contacts are actually open and the requirements for the isolating function have been satisfied;
- c) have an external operating means (for example, handle);
- d) be provided with a means (integral or external) permitting it to be locked only in the OFF (isolated) position (for example, by padlocks). When so locked, remote as well as local closing shall be prevented;
- e) disconnect all live conductors of its power supply circuit. However, for TN (TN-S) supply systems, the neutral conductor may or may not be disconnected if the fabrication equipment is to be used in Japan or in other countries where any rule on disconnection of the neutral conductor is absent. Where the neutral conductor can be disconnected it shall be disconnected simultaneously with the phase conductors. The PE conductor and PEN conductor shall not be disconnected in any earthing system;

NOTE : A TN system is one in which one point is directly earthed, with a protective conductor (PE) directly connected to that point. TN-S system is that in which PE conductor is separated from N conductor (neutral conductor) throughout the TN system. TN system is not used in the commercial power supply in Japan. See Annex E and **JIS C 60364-1**.

- f) have a breaking capacity sufficient to interrupt the current of the largest motor when stalled together with the sum of the normal running currents of all other motors and/or loads that can be operated at any time.

5.3.4 Operating means

The operating means (for example, a handle) of the supply disconnecting device shall be readily accessible and located not more than 2 m above the servicing level. A height of between 0.6 m and 1.7 m is recommended.

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

5.3.5 Supply disconnecting device mounting

The supply disconnecting device shall be installed in accordance with one or more of the following:

- a) in its own electrical enclosure on or adjacent to the equipment for which it provides a disconnecting means;
- b) near the top of the electrical enclosure for which it provides a disconnecting means;
- c) anywhere below the top of the electrical enclosure for which it provides a disconnecting means provided that its incoming terminations are guarded to prevent accidental contact by personnel or by a tool dropped from above. Compliance can be demonstrated by verifying that a probe 3 mm in diameter and 15 mm long cannot contact live parts (see test probe 13 of **JIS C 0922**).

Exception: Machines with a nominal power consumption of 1 500 W or less may be connected to a remotely mounted supply disconnecting device, provided that device is readily accessible and no more than 6 m from the machine.

5.3.6 Supply disconnecting device door interlock

Doors that provide access to live parts of the supply disconnecting device, shall be interlocked so that the door can only be opened when the supply disconnecting device is open and so that the supply disconnecting device can only be closed when the door is closed.

A tool or special device as prescribed by the supplier may be provided to permit skilled and instructed persons to defeat the interlock, provided that protection is provided against inadvertent contact with hazardous-live-parts inside the enclosure by the measures defined in 6.5.

Exception: Supply disconnecting device door interlocking need not be provided where protection is provided against inadvertent contact with hazardous-live-parts inside the enclosure by the measures defined in 6.5 for loads that:

- are rated less than 5 kVA, or
- consist of lighting circuits, or
- are cord and plug connected electrical equipment.

5.3.7 UPS disconnection

The output of each UPS that can supply greater than 30 V r.m.s., 42.4 V peak, 60 V d.c. or 240 VA,

- shall be disconnected when the main disconnecting device is opened or
- shall be provided with a disconnecting means that satisfies all the requirements for the supply disconnecting device in 5.3.1 to 5.3.5, or both.

The UPS output wiring and terminals shall be labelled as “UPS Output”, or equivalent, at each connection point where the UPS wiring can be disconnected.

All power supplied from the UPS shall be disconnected when the emergency off actuator is activated.

Exception: Power supplied from the UPS to safety related devices (including EMO circuits) and computer systems that perform functions such as data/alarm logging and error recovery is excepted from this requirement.

5.4 Additional disconnecting devices

Where it can be necessary to perform work on parts of the fabrication equipment (e.g. motors) when they are de-energized and isolated while leaving other parts of the electrical equipment energized, then a separate disconnecting device shall be provided for each part requiring separate isolation.

Such disconnecting devices should be:

- appropriate and convenient for the intended use;
- suitably located;
- readily identifiable as to which part or circuit(s) of the electrical equipment is served (e.g. by durable marking where necessary).

Means shall be provided to prevent unauthorized, inadvertent, and/or mistaken closure of these devices (e.g. provisions for locking).

Motors installed in a location from which the supply disconnecting device is not visible (for example, in a case or sub-fab) shall be provided with an additional means of disconnecting all unearthed conductors within sight of, and not more than 3 m distance from, the motor. These means of disconnecting shall meet the requirements of **5.3.1** to **5.3.5**.

5.5 Protection against unauthorized, inadvertent and/or mistaken connection of plug/socket combination

When a plug/socket combination is used as a supply disconnecting means during maintenance or repair, in addition to meeting the requirements of **5.3.2 d**), it shall either be capable of being kept under the exclusive supervision of the person carrying out the maintenance or repair, or it shall be provided with a lockable means to prevent it from being connected unintendedly.

6 Protection against electric shock

6.1 General

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

- direct contact (see **6.2**);
- indirect contact (see **6.3**).

NOTE : It is considered that some of the protection against electric shock of skilled persons is provided by their training and experience.

Skilled and instructed persons are those having appropriate technical training and experience to be aware of hazards to which they are exposed; however, inadvertent and unexpected electric shock is liable to occur. Skilled and instructed persons shall be protected against inadvertent and unexpected electric shock in accordance with **6.5**.

The recommended measures for this protection are given in **6.2**, **6.3**, **6.4**, and **6.5**.

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 be applied.

When the electrical equipment is located in places open to persons other than skilled and instructed persons, measures of either **6.2.2** with a minimum degree of protection against direct contact corresponding to IP2X/IPXXB (see **JIS C 0920**), or **6.2.3** shall be applied.

6.2.2 Protection by enclosures

Opening an enclosure other than that of the supply disconnecting device (see **5.3.6**) that contains hazardous-live-parts (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.

NOTE : The necessity to use a key or tool is intended to restrict access to skilled or instructed persons.

Skilled and instructed persons shall be protected against inadvertent contact with hazardous-live-parts inside the enclosure by the measures defined in **6.5**.

- b) The disconnection of hazardous-live-parts inside the enclosure before the enclosure may be opened. This shall either be accomplished by a mechanical and/or electrical interlock so that the door can only be opened when the hazardous supply is disconnected and so that the hazardous supply can only be connected when the door is closed. If an electrical interlock is used, it shall meet all the requirements of clause **9** for a protective interlock circuit.

Exception: a special device or tool as prescribed by the supplier may be provided to permit skilled and instructed persons to defeat the interlock, provided that protection is provided against inadvertent contact with hazardous-live-parts inside the enclosure by the measures defined in **6.5**.

Any hazardous-live-parts that are not disconnected shall be marked with a warning sign in accordance with **16.2**, except for the supply terminals of the supply disconnecting device when it is mounted alone in a separate enclosure.

- c) Opening without the use of a key or a tool and without disconnection of hazardous-live-parts shall be possible only when all hazardous-live-parts are protected against direct contact to at least IP2X or IPXXB. Where protection is removable, either it shall require a tool for its removal or all live parts protected by it shall be automatically disconnected when the protection is removed.

6.2.3 Protection by insulation of live parts

Live parts protected by insulation shall be completely covered with insulation that can only be removed by destruction. Such insulation shall be capable of withstanding the mechanical, chemical, electrical, and thermal stresses to which it can be subjected under normal operating conditions.

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

6.2.4 Protection against residual voltages

Live parts having a residual voltage greater than 60 V after the supply has been disconnected shall be discharged to 60 V and 20 J or less within a time period of 10 s after disconnection of the supply voltage provided that this rate of discharge does not interfere with the proper functioning of the fabrication equipment.

Electrical equipment that cannot be discharged to this level in 10 s is exempted from this requirement if the following conditions are satisfied:

- the conductors supplied with stored energy cannot be accessed without the removal of a panel that requires a tool to remove; and
- the panel that is removed to access those conductors is marked specifying the discharge time required for the discharge conditions to be less than both 60 V and 20 J; and
- the discharge time does not exceed 5 min.

In the case of plugs or similar devices, the withdrawal of which results in the exposure of conductors (for example, pins), the discharge time shall not exceed 1 s, otherwise such conductors shall be protected against direct contact to at least IP2X or IPXXB. If neither a discharge time of 1 s nor a protection of at least IP2X or IPXXB can be achieved, additional switching devices for discharge or an appropriate warning device (for example, a warning notice in accordance with **16.2**) shall be applied.

NOTE : Voltage supplied by a UPS is considered to be a battery source and is not considered to be a residual voltage.

6.3 Protection against indirect contact

6.3.1 General

Protection against indirect contact (**3.38**) is intended to prevent hazardous situations due to an insulation fault between live parts and exposed conductive parts.

For each circuit or part of the electrical equipment, at least one of the following measures in accordance with **6.3.2** to **6.3.3** shall be applied:

- measures to prevent the occurrence of a touch voltage (**6.3.2**), or
- automatic disconnection of the supply before the time of contact with a touch voltage can become hazardous (**6.3.3**).

NOTE 1 The risk of harmful physiological effects from a touch voltage depends on the value of the touch voltage and the duration of possible exposure.

NOTE 2 For classes of electrical equipment and protective provisions, see **JIS C 0365**. There are Class I, Class II and Class III.

6.3.2 Prevention of the occurrence of a touch voltage

6.3.2.1 General

Measures to prevent the occurrence of a touch voltage include the following:

- provision of Class II equipment or by equivalent insulation (**6.3.2.2**);
- electrical separation (**6.3.2.3**).

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

This measure is intended to prevent the occurrence of touch voltages on the accessible parts through a fault in the basic insulation.

NOTE : Examples of this measure include:

- Class II electrical devices or apparatus (**3.14**);

- switchgear and controlgear assemblies having total insulation in accordance with **IEC 61439-1**.

6.3.2.3 Protection by electrical separation

6.3.2.3.1 General

Electrical separation of an individual circuit is intended to prevent a hazardous touch voltage through contact with exposed conductive parts that can be energized by a fault in the basic insulation of the live parts of that circuit. In order to provide this type of protection either the requirement of both sub-clauses **6.3.2.3.2** and **6.3.2.3.3** shall be satisfied or the requirements for electrical separation in **JIS C 60364-4-41** shall be satisfied.

6.3.2.3.2 Isolated power systems

The circuit to be protected by electrical separation shall have a high impedance between its conductors and the incoming supply connection to the equipment and a high impedance to earth. Impedance of one megohm or more is considered to be sufficiently high. This can be achieved by the use of isolation transformers or power supplies that have no direct electrical connection between their primary conductors and their secondary conductors.

NOTE 1 An isolation transformer with one conductor of the secondary connected to ground is not an isolated power system.

NOTE 2 Auto transformers do not provide electrical isolation.

NOTE 3 Isolated power systems are commonly used to reduce sources of electronic noise by not deliberately referencing the output circuit conductors to earth (ground).

6.3.2.3.3 Requirements for isolated circuits

Isolated circuits shall meet the following requirements:

- the transformer or power supply, and any components (devices) connected to their output, shall be clearly labelled adjacent to the isolated circuit(s) or on the enclosure to warn operators and service personnel of the unearthed condition, and
- earth fault detection lights, an insulation monitoring device, or a device that interrupts the circuit automatically in the event of an earth fault shall be installed.

6.3.3 Protection by automatic disconnection of supply

This protective measure consists of the interruption of one or more of the line conductors by the automatic operation of a protective device in case of an insulation fault. It is intended to prevent a hazardous situation by interrupting the supply within a sufficiently short time to limit the duration of a touch voltage to a time within which that voltage is not hazardous.

Requirements for TN supply systems are given in Annex A. A protective circuit impedance ($0.1\ \Omega$) in accordance with **18.2.5** can be considered sufficiently low to meet the requirements of Annex A.

Requirements for TT supply systems are given in Annex B.

NOTE 1 A TT supply system is one in which one point is directly earthed but the protective conductor (PE) of the equipment is not directly connected to that earth point of the electrical supply system but directly connected to other earth point. See Annex E and **JIS C 60364-1**.

NOTE 2 Internationally TN supply systems are commonly preferred over TT supply systems.

NOTE 3 In Japan TT supply systems are commonly used.

NOTE 4 This protective measure can necessitate co-ordination between:

- the type of supply and earthing system (e.g. TT, TN);
- the impedance values of the different elements of the protective bonding system;
- the characteristics of the protective devices that detect insulation fault(s).

This protective measure comprises both

- protective bonding of exposed conductive parts (see **8.2.3**), and
- one of the following [In Japan, **b**) is commonly used.]:
 - a) overcurrent protective devices for automatic disconnection of the supply on detection of an insulation fault in TN systems, or
 - b) residual current protective devices to initiate the automatic disconnection of the supply on detection of an insulation fault from a live part to exposed conductive parts or to earth in TT systems, or
 - c) insulation monitoring or residual current protective devices to initiate automatic disconnection of IT systems. Except where a protective device is provided to interrupt the supply in the case of the first earth fault, an insulation monitoring device shall be provided to indicate the occurrence of a first fault from a live part to exposed conductive parts or to earth. This insulation monitoring device shall initiate an audible and/or visual signal which shall continue as long as the fault persists.

Where automatic disconnection is provided in accordance with **a**), and disconnection within the time specified in clause **A.1** cannot be assured, supplementary bonding shall be provided as necessary to meet the requirements of clause **A.3**.

6.4 Protection by the use of PELV

NOTE : PELV (protective extra-low voltage) means a voltage not exceeding ELV (extra-low voltage) in the steady-state or single-fault condition. PELV circuit is earthed. ELV circuit not earthed is called SELV. The voltage value of ELV does not exceed 50 V a.c. or 120 V d.c. according to the definition in **JIS C 0366** (band I), but the required value of PELV can differ from this definition according to some application standards. In **6.4.1** of this Standard, severer values than this definition are specified.

6.4.1 General requirements

The use of PELV (protective extra-low voltage) is intended to protect persons against electric shock from indirect contact and limited area direct contact (protect persons from injury even if they contact).

PELV circuits shall satisfy all of the following conditions:

- a) the nominal voltage shall not exceed:
 - 25 V a.c. r.m.s. or 60 V ripple-free d.c. when the fabrication equipment is normally used in dry locations and when large area contact of live parts with the human body is not expected; or
 - 6 V a.c. r.m.s. or 15 V ripple-free d.c. in all other cases;
- NOTE : Ripple-free is conventionally defined for a sinusoidal ripple voltage as a ripple content of not more than 10 % r.m.s.
- b) one side of the circuit or one point of the source of the supply of that circuit shall be connected to the protective bonding circuit;
 - c) live parts of PELV circuits shall be electrically separated from other live circuits. Electrical separation shall be not less than that required between the primary and secondary circuits of a safety isolating transformer (see **JIS C 61558-1** and **JIS C 61558-2-6**);
 - d) conductors of each PELV circuit shall be physically separated from those of any other circuit. When this requirement is impracticable, the insulation provisions of **13.1.3** shall apply;
 - e) plugs and socket-outlets for a PELV circuit shall conform to the following:
 - plugs shall not be able to enter socket-outlets of other voltage systems;
 - socket-outlets shall not admit plugs of other voltage systems.

6.4.2 Sources for PELV

The source for PELV shall be one of the following:

- a safety isolating transformer in accordance with **JIS C 61558-1** and **JIS C 61558-2-6**;
- a source of current 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 source (for example, a battery) or another source 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, even in the case of an internal fault, the voltage at the outgoing terminals cannot exceed the values specified in **6.4.1**.

6.4.3 Design to minimise risks of live working

The electrical equipment shall be designed to minimize the need to calibrate, modify, repair, test, adjust, or maintain equipment while it is energized, and to minimize the need for work to be performed on components near exposed hazardous energized circuits.

Appropriate safety procedures (e.g., use of appropriate personal protective equipment and barriers) for troubleshooting, shall be described in the instructions for use. See **17.2**.

6.5 Protection of skilled persons and instructed persons against inadvertent contact with hazardous-live-parts

6.5.1 General

Inadvertent contact to circuits that are not PELV shall be prevented by design. Persons shall not be inadvertently exposed to electrical or mechanical hazards while performing manual adjustments. Adequate access shall be provided for maintenance and repair. Where maintenance and repair personnel need to access the electrical equipment while it is energized, live parts (other than PELV) shall be protected against inadvertent contact by the provision of obstacles. Obstacles shall be provided where it is necessary to reach over, under, around, or close to electrical hazards. They shall also be provided where dropped objects or failure of liquid fittings could result in short circuits or arcing.

6.5.2 Obstacles

Obstacles that are used to protect against inadvertent contact shall be made of non-conductive material or if made of conductive material they shall be earthed. They shall be of substantial construction sufficient to withstand foreseeable abuse.

6.5.3 Probe holes

When necessary for electrical testing, probe holes shall be provided in the obstacles. These probe holes shall be located over test points and designed to protect against inadvertent contact with live parts. They should also provide adequate access for a test probe where it is needed and they shall be identified in the information for use (see **17.2**). Where obstacles are of conductive material the perimeter of the probe holes shall be insulated.

7 Protection of equipment

NOTE : The term “equipment” specified in clause **7** mainly means single electrical item (such as transformer, motor and conductor) (see **3.20**).

7.1 General

This clause details the measures to be taken to protect equipment against the effects of:

- overcurrent including the effect of a short circuit;
- overload and/or loss of cooling of motors;
- abnormal temperature;
- loss of or reduction in the supply voltage;
- overspeed of machines/machine elements;
- earth fault/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 in all circuits that can be supplied with hazardous electrical power under normal operations or single fault conditions where current can exceed either the rating of any component or the current carrying capacity of the conductors, whichever is the lesser value. The ratings or settings to be used are detailed in **7.2.9**.

7.2.2 Supply conductors

NOTE : The term “supply conductors” specified in **7.2.2** means distributions (provided by the user of the electrical equipment) outside the incoming supply terminals of the electrical equipment and generally not contained in the structure of the electrical equipment.

The supplier of the electrical equipment is not responsible for providing the overcurrent protective device for the supply conductors to the electrical equipment.

The supplier of the electrical equipment shall state on the installation documentation the data necessary for selecting the overcurrent protective device (see **7.2.9** and **17.4**).

7.2.3 Neutral conductor protection

In TN or TT systems, neutral conductors shall not be disconnected without disconnecting the associated live conductors. Where the cross-sectional area of the neutral conductor is at least equal to or equivalent to that of the phase conductors, it is not necessary to provide overcurrent detection for the neutral conductor nor automatic disconnection for that conductor. For a neutral conductor with a cross-sectional area smaller than that of the associated phase conductors, the measures detailed in **431.2.1** of **JIS C 60364-4-43** shall apply.

In IT systems, it is recommended that the neutral conductor is not used. However, where a neutral conductor is used, the recommendations detailed in **431.2.2** of **JIS C 60364-4-43** are applicable.

NOTE : An IT system is a distribution system that is not directly earthed. See Annex E.

7.2.4 Socket outlets and their associated conductors

Where general purpose socket outlets are provided for supplying power to maintenance equipment, overcurrent protective devices shall be provided in the unearthed live conductors of each circuit feeding such socket outlets in accordance with **7.2.9**.

7.2.5 Lighting circuits

All unearthed conductors of circuits supplying lighting shall be protected against the effects of short circuits by the provision of overcurrent devices (exclusive for lighting circuits) independent of those protecting other circuits in accordance with **7.2.9**.

7.2.6 Transformers

Transformers shall be protected against overcurrent in accordance with the transformer manufacturer's instructions and with **7.2.9**. If the manufacturer's instructions differ from the requirements of **7.2.9**, the more stringent requirements shall apply.

7.2.7 Location of overcurrent protective devices

An overcurrent protective device shall be located at the point where a reduction in the cross-sectional area of each conductor or another change reduces the current-carrying capacity of the conductor such that it is not protected by the upstream protective device, except where all the following conditions are satisfied:

- the current carrying capacity of the conductor is at least equal to that of the load;
- the part of the conductor between the point of reduction of current-carrying capacity and the position of the overcurrent protective device is no longer than 3 m;
- the conductor is installed in such a manner as to reduce the possibility of a short-circuit, for example, protected by an enclosure or duct.

7.2.8 Overcurrent protective devices

7.2.8.1 General

The short-circuit rating of overcurrent protective devices (see NOTE 4) shall be at least equal to the prospective fault current at their point of connection when the equipment is connected to an incoming supply as specified by the equipment manufacturer. Where the short-circuit current to an overcurrent protective device can include additional currents other than from the supply (for example, from motors, from power factor correction capacitors), those currents shall be taken into consideration.

The characteristics of two series connected OCPDs devices shall be coordinated so that the let-through energy (I^2t) of the two devices in series does not exceed that which can be withstood without damage to the overcurrent protective device on the load side and to the conductors protected by that device. This can be determined by tests and/or by calculation.

NOTE 1 See for example Annex A of **JIS C 60947-2**. Other techniques for the evaluation can be found in, for example, **SEMI S22**, **UL 508A**.

NOTE 2 The use of such a co-ordinated arrangement of overcurrent protective devices can result in the operation of both overcurrent protective devices.

NOTE 3 Circuit breakers are commonly preferred to fuses.

NOTE 4 The short-circuit rating of overcurrent protective devices is equivalent to the rated short-circuit breaking capacity.

Overcurrent protective devices include fuses and circuit-breakers. Electronic devices designed to reduce or to limit the current in protected circuits may also be used.

7.2.8.2 Additional requirements for fuses

When fuses are provided they shall be in fixed fuse holders.

7.2.8.3 Additional requirements for circuit-breakers

All circuit breakers shall have the OFF (isolated) position and ON position clearly marked with “○” and “I” (symbols **IEC 60417-5008** and **IEC 60417-5007**, see **10.2.2**).

Actuating directions shall be in accordance with the following:

- Circuit breakers that are mounted on a vertical surface and vertically oriented shall be mounted with the handle up for the “ON” position.
- Circuit breakers that are mounted on a vertical surface and horizontally oriented shall be mounted with the handle to the right for the “ON” position.
- Circuit breakers that are mounted in two columns, horizontally oriented, shall be mounted with the handles toward the centre for the “ON” position; or clearly marked indicating the “ON” and “OFF” positions.
- Circuit breakers that are mounted on a horizontal surface shall be mounted with the handle to the right for the “ON” position.

7.2.9 Rating and setting of overcurrent protective devices

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

Overcurrent protection shall be limited as follows.

- Conductors and plug/socket combinations shall have overcurrent protection that does not exceed their rating.
- The overcurrent protection of other devices or components, with the exception of motors, shall not exceed 125 % of the current rating of the device or component or 125 % of maximum nominal load.
- Non-process lighting circuits shall have overcurrent protection at not greater than 15 A.
- Transformers that operate at 50/60 Hz shall be protected in accordance with table 1 or table 2 as appropriate.

Table 1 Protection of transformers without thermal protection

Transformer primary rating	Transformer secondary rating	Maximum primary protection percentage of rating (%)	Maximum secondary protection percentage of rating (%)
Any rating	≥ 9 A	250	125
Any rating	< 9 A	250	167
≥ 9 A	Any rating	125	Not required
< 9 A and > 2 A	Any rating	167	Not required
≤ 2 A	Any rating	300	Not required