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

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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 of 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 9960-32:2004** is replaced with this Standard.

This **JIS** document is protected by the Copyright Law.

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 or utility model right. 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 or the utility model right.

JIS B 9960 consists of the following 4 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 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV

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 32: Requirements for hoisting machines

Introduction

This Japanese Industrial Standard has been prepared based on the second edition of **IEC 60204-32** published in 2008 with some modifications of the technical contents.

The portions given solid sidelines or dotted underlines, Annex JA and Annex JB are the matters not contained in the corresponding International Standard. A list of modifications and their explanations is given in Annex JC.

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

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

High performance is not to be obtained at the expense of the essential factors mentioned above.

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

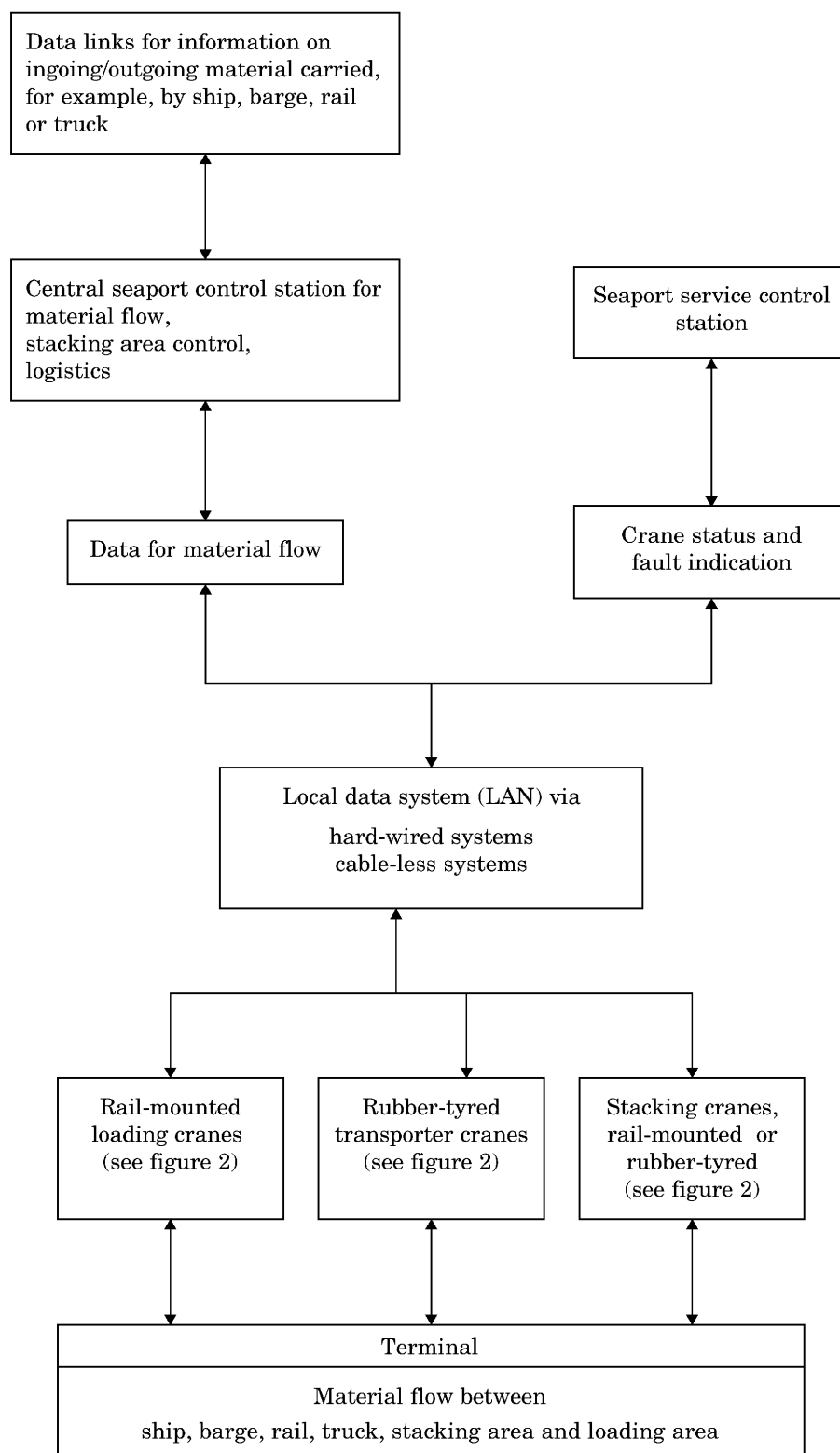


Figure 1 Block diagram of combined working cranes in a typical material handling system in a seaport

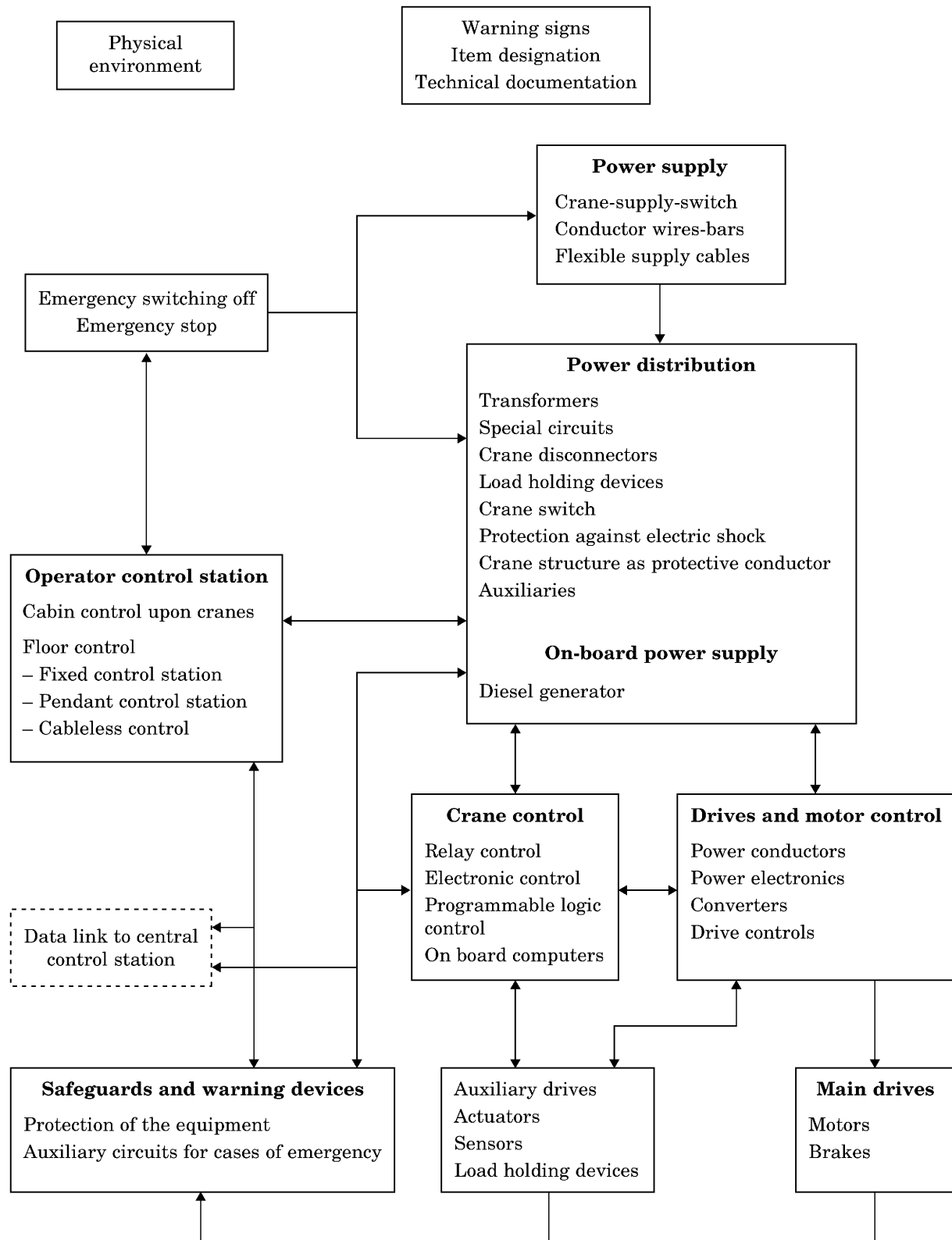


Figure 2 Block diagram of a typical crane and its associated electrical equipment

1 Scope

This Standard applies to the application of electrical and electronic equipment and systems to hoisting machines and related equipment.

NOTE 1 In this Standard, the term “electrical” includes both electrical and electronic matters (i.e. “electrical equipment” means both the electrical and the 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 user’s agent(s) in the use and care of the hoisting machine in question.

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

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

This Standard is applicable to equipment or parts of equipment not exceeding 1 000 V a.c. or 1 500 V d.c. between lines and with nominal frequencies not exceeding 200 Hz.

NOTE 4 For equipment exceeding 1 000 V a.c. or 1 500 V d.c. and not more than 36 kV, the requirements shall be as given in **JIS B 9960-11**.

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

- are intended for use in open air (i.e., outside buildings or other protective structures);
- handle or transport potentially explosive material (for example, paint or sawdust);
- are intended for use in potentially explosive and/or flammable atmospheres;
- are intended for use in mines.

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

- overhead travelling cranes;
- mobile cranes;
- tower cranes;
- slewing luffing cranes;
- gantry cranes;
- offshore cranes;
- floating cranes;
- winches of all types;

- hoists and accessories;
- loader cranes;
- container cranes;
- cable cranes;
- load holding devices;
- storage and retrieval machines;
- monorail hoists;
- straddle carriers;
- rubber tyred gantry cranes (RTGs).

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

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

IEC 60204-32:2008 *Safety of machinery—Electrical equipment of machines—Part 32: Requirements for hoisting machines* (MOD)

The 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 of the referenced documents (including amendments) shall be applied.

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 9703:2011 *Safety of machinery—Emergency stop—Principles for design*

NOTE : Corresponding International Standard: ISO 13850:2006 *Safety of machinery—Emergency stop—Principles for design* (IDT)

JIS B 9705-1:2011 *Safety of machinery—Safety-related parts of control systems—Part 1: General principles for design*

NOTE : Corresponding International Standard: ISO 13849-1:2006 *Safety of machinery—Safety-related parts of control systems—Part 1: General principles for design* (IDT)

JIS B 9706-1:2009 *Safety of machinery—Indication, marking and actuation—Part 1: Requirements for visual, acoustic and tactile signals*

NOTE : Corresponding International Standard: IEC 61310-1:2007 *Safety of machinery—Indication, marking and actuation—Part 1: Requirements for visual, acoustic and tactile signals* (IDT)

JIS B 9706-2:2009 *Safety of machinery—Indication, marking and actuation—Part 2: Requirements for marking*

NOTE : Corresponding International Standard: IEC 61310-2:2007 *Safety of machinery—Indication, marking and actuation—Part 2: Requirements for marking* (IDT)

JIS B 9706-3:2009 *Safety of machinery—Indication, marking and actuation—Part 3: Requirements for the location and operation of actuators*

NOTE : Corresponding International Standard: IEC 61310-3:2007 *Safety of machinery—Indication, marking and actuation—Part 3: Requirements for the location and operation of actuators* (IDT)

JIS B 9707:2002 *Safety of machinery—Safety distances to prevent danger zones being reached by the upper limbs*

NOTE : Corresponding International Standard: ISO 13852:1996 *Safety of machinery—Safety distances to prevent danger zones being reached by the upper limbs* (IDT)

JIS B 9712:2006 *Safety of machinery—Two-hand control devices—Functional aspects and design principles*

NOTE : Corresponding International Standard: ISO 13851:2002 *Safety of machinery—Two-hand control devices—Functional aspects and design principles* (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 0365:2007 *Protection against electric shock—Common aspects for installation and equipment*

NOTE : Corresponding International Standard: IEC 61140:2001 *Protection against electric shock—Common aspects for installation and equipment* and Amd. 1:2004 (IDT)

JIS C 0445:1999 *Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system*

NOTE : Corresponding International Standard: IEC 60445:1988 *Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system* (IDT)

JIS C 0446:1999 *Identification of conductors by colours or numerals*

NOTE : Corresponding International Standard: IEC 60446:1989 *Identification of conductors by colours or numerals* (MOD)

JIS C 0447:1997 *Man-machine interface (MMI)—Actuating principles*

NOTE : Corresponding International Standard: IEC 60447:1993 *Man-machine interface (MMI)—Actuating principles* (IDT)

JIS C 0448:1997 *Coding of indicating devices and actuators by colours and supplementary means*

NOTE : Corresponding International Standard: IEC 60073:1991 *Coding of indicating devices and actuators by colours and supplementary means* (IDT)

JIS C 0452-1:2004 *Industrial systems, 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 0454:2005 *Structuring of technical information and documentation*

NOTE : Corresponding International Standard: IEC 62023:2000 *Structuring of technical information and documentation* (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 (Part 1 to Part 13) *Graphical symbols for diagrams*

NOTE : Corresponding International Standards: IEC 60617 (all Parts) *Graphical symbols for diagrams* (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*, Amd. 1:1995 and Amd. 2:1996 (MOD)

JIS C 3665 series *Tests on electric and optical fibre cables under fire conditions*

NOTE : Corresponding International Standards: IEC 60332:2004 (all parts) *Tests on electric and optical fibre cables under fire conditions* (IDT)

JIS C 4034-1:1999 *Rotating electrical machines Part 1: Rating and performance*

NOTE : Corresponding International Standard: IEC 60034-1:1996 *Rotating electrical machines—Part 1: Rating and performance* and Amd. 1:1997 (NEQ)

JIS C 4034-5:1999 *Rotating electrical machines—Part 5: Classification of degrees of protection provided by enclosures of rotating electrical machines (IP code)*

NOTE : Corresponding International Standard: IEC 60034-5:1991 *Rotating electrical machines—Part 5: Classification of degrees of protection provided by enclosures of rotating electrical machines (IP code)* (IDT)

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

NOTE : Corresponding International Standard: IEC 60034-1:1996 *Rotating electrical machines—Part 1: Rating and performance* and 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* (overall evaluation: MOD)

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

NOTE : Corresponding International Standard: IEC 60034-1:1996 *Rotating electrical machines—Part 1: Rating and performance* and 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* (overall evaluation: MOD)

JIS C 4212:2010 *Low-voltage three-phase squirrel-cage high-efficiency induction motors*

JIS C 8201-1:2007 *Low-voltage switchgear and controlgear—Part 1: General rules*

NOTE : Corresponding International Standard: IEC 60947-1:2004 *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* (MOD)

JIS C 8201-3:2009 *Low-voltage switchgear and controlgear—Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*

NOTE : Corresponding International Standard: IEC 60947-3:1999 *Low-voltage switchgear and controlgear—Part 3: Switches, disconnectors, switch-disconnectors, and fuse-combination units*, Amd. 1:2001 and Amd. 2:2005 (MOD)

JIS C 8201-4-1:2007 *Low-voltage switchgear and controlgear—Part 4-1: Contactors and motor-starters: Electromechanical contactors and motor-starters*

NOTE : Corresponding International Standard: IEC 60947-4-1:2000 *Low-voltage switchgear and controlgear—Part 4-1: Contactors and motor-starters—Electromechanical contactors and motor-starters* and Amd. 1:2002 (MOD)

JIS C 8201-5-1:2007 *Low-voltage switchgear and controlgear—Part 5-1: Control circuit devices and switching elements—Electromechanical control circuit devices*

NOTE : Corresponding International Standard: IEC 60947-5-1:2003 *Low-voltage switchgear and controlgear—Part 5-1: Control circuit devices and switching elements—Electromechanical control circuit devices* (IDT)

JIS C 8285:2010 *Plugs, socket-outlets and couplers for industrial purposes*

NOTE : Corresponding International Standard: IEC 60309-1:1999 *Plugs, socket-outlets and couplers for industrial purposes—Part 1: General requirements* and Amd. 1:2005 (MOD)

JIS C 60068-2-27:1995 *Basic environmental testing procedures—Part 2: Tests, Test Ea and guidance: Shock*

NOTE : Corresponding International Standard: IEC 60068-2-27:1987 *Environmental testing. Part 2: Tests. Test Ea and guidance: Shock* (IDT)

JIS C 60068-2-32:1995 *Environmental testing Part 2: Tests. Test Ed: Free fall*

NOTE : Corresponding International Standard: IEC 60068-2-32:1975 *Environmental testing. Part 2: Tests. Test Ed: Free fall*, Amd. 1:1982 and Amd. 2:1990 (IDT)

JIS C 60364-1:2010 *Low-voltage electrical installations—Part 1: Fundamental principles, assessment of general characteristics, definitions*

NOTE : Corresponding International Standard: IEC 60364-1:2005 *Low-voltage electrical installations—Part 1: Fundamental principles, assessment of general characteristics, definitions* (IDT)

JIS C 60364-4-41:2010 *Low-voltage electrical installations—Part 4-41: Protection for safety—Protection against electric shock*

NOTE : Corresponding International Standard: IEC 60364-4-41:2005 *Low-voltage electrical installations—Part 4-41: Protection for safety—Protection against electric shock* (IDT)

JIS C 60364-4-42:2006 *Electrical installations of buildings—Part 4-42: Protection for safety—Protection against thermal effects*

NOTE : Corresponding International Standard: IEC 60364-4-42:2001 *Electrical installations of buildings—Part 4-42: Protection for safety—Protection against thermal effects* (IDT)

JIS C 60364-4-43:2006 *Low-voltage electrical installations—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 60364-5-53:2002 *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 60364-6:2010 *Low-voltage electrical installations—Part 6: Verification*

NOTE : Corresponding International Standard: IEC 60364-6:2006 *Low-voltage electrical installations—Part 6: Verification* (IDT)

JIS C 60664-1:2009 *Insulation coordination for equipment within low-voltage systems—Part 1: Principles, requirements and tests*

NOTE : Corresponding International Standard: IEC 60664-1:2007 *Insulation coordination for equipment within low-voltage systems—Part 1: Principles, requirements and tests* (IDT)

JIS C 61558-1:2008 *Safety of power transformers, power supplies, reactors and similar products—Part 1: General requirements and tests*

NOTE : Corresponding International Standard: IEC 61558-1:2005 *Safety of power transformers, power supplies, reactors and similar products—Part 1: General requirements and tests* (MOD)

JIS C 61558-2-6:2008 *Safety of power transformers, power supply units and similar—Part 2-6: Particular requirements for safety isolating transformers for general use*

NOTE : Corresponding International Standard: IEC 61558-2-6:1997 *Safety of power transformers, power supply units and similar—Part 2: Particular requirements for safety isolating transformers for general use* (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 60072-1 *Dimensions and output series for rotating electrical machines—Part 1: Frame numbers 56 to 400 and flange numbers 55 to 1080*

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

IEC 60417 *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* and Amd. 1: 2004

IEC 60898 (all parts) *Electrical accessories—Circuit-breakers for overcurrent protection for household and similar installations*

IEC 61180-2:1994 *High-voltage test techniques for low-voltage equipment—Part 2: Test equipment*

IEC 61557-3 *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 61800-5-2:2007 *Adjustable speed electrical power drive systems—Part 5-2: Safety requirements—Functional*

IEC 61984 *Connectors—Safety requirements and tests*

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 Note the difference between actuator and machine actuator (**3.44**). The machine actuator is not a means of operation.

3.2 ambient temperature

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

3.3 (electrically) protective barrier

part providing protection against direct contact from any usual direction of access (see **IEV 826-12-23**)¹⁾

Note ¹⁾ **IEV**: International Electrotechnical Vocabulary, specified in **IEC 60050** series. In this instance, **IEV 826-12-23** means **IEC 60050-826-12-23** (the same applies hereafter).

3.4 cabin-controlled hoisting machine

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

3.5 cable tray

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

NOTE : A cable tray may be perforated or mesh (see **IEV 826-15-08**).

3.6 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

NOTE : A cable trunking system falls under the category of a cable duct (see **3.21**).

3.7 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)

3.8 conduit

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

NOTE : Conduits should be sufficiently closed-jointed so that the insulated conductors and/or cables can only be drawn in and not inserted laterally (see **IEV 826-15-03**).

3.9 control circuit (of a hoisting machine)

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

3.10 control device

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

3.11 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 in principle for the control of electrical energy consuming equipment (**IEV 441-11-03**, modified)

3.12 controlled stop

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

3.13 crane

machine for hoisting/lowering and horizontally relocating suspended loads

3.14 crane-disconnector

hand-operated disconnecting device installed on a hoisting machine for disconnecting (isolating) a supply circuit (for example, for repair or maintenance work)

3.15 crane-supply-switch

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

3.16 crane-switch

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

3.17 (continuous) current-carrying capacity, ampacity

maximum value of electric current which can be carried continuously by a conductor or an apparatus, under specified conditions without its steady-state temperature exceeding a specified value (see **IEV 826-11-13**)

3.18 direct contact

electric contact of persons or animals with live parts (see **IEV 826-12-03**)

3.19 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) (see **JIS C 8201-5-1, K.2.2**)

3.20 disconnecting device

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

3.21 duct

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

NOTE : Conduits (see **3.8**), cable trunking systems (see **3.6**) and underfloor channels are types of duct. A channel refers to a round duct, a square channel, etc.

3.22 electrical operating area

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

3.23 electronic equipment

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

3.24 emergency stop device

manually actuated control device used to initiate an emergency stop function (see **JIS B 9703, 3.2**)

NOTE : See Annex E.

3.25 emergency switching-off device

manually actuated control device used to switch off the supply of electrical energy to all or a part of an installation where a risk of electric shock or another risk of electrical origin is involved

NOTE : See Annex E.

3.26 enclosed electrical operating area

room or location for electrical equipment to which access is intended to be restricted to skilled or instructed persons by the opening of 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

3.27 enclosure

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

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

- a) Enclosures (see **JIS C 0920**) provide protection of persons or livestock against access to hazardous parts.

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

3.28 equipment

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

3.29 equipotential bonding

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

3.30 exposed conductive part

conductive part of electrical equipment which can be touched and which is not normally live but which can become live under fault conditions (**IEV 826-12-10**, modified)

3.31 extraneous conductive part

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

3.32 failure

termination of the ability of an item²⁾ 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.

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

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

Note ²⁾ An item refers to a component of an electrical equipment or a system.

3.33 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 (see **IEV 191-05-01**)

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

3.34 functional bonding

equipotential bonding necessary for proper functioning of electrical equipment

3.35 guard

part of a hoisting machine specifically used to provide protection by means of a physical barrier

Depending on its construction, a guard may be called casting, cover, screen, door, enclosing guard, etc. (**JIS B 9700-1, 3.25**, modified).

3.36 hand-held direct-control device

manually operated switching device, the enclosure of which is portable by hand during operation, acting direct on a power circuit

3.37 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, electric 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)

3.38 indirect contact

electric contact of persons or animals with exposed conductive parts which have become live under fault conditions (see **IEV 826-12-04**)

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 hoisting 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 electrically skilled persons to enable him or her to perceive risks and to avoid hazards which electricity can create (see **IEV 826-18-02**)

3.41 interlock (for safeguarding)

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

3.42 limiting device

device which prevents a hoisting machine or a hoisting machine element from exceeding a designed limit (for example, space limit, pressure limit) (see **JIS B 9700-1, 3.26.8**)

3.43 live part

conductor or conductive part intended to be energized in normal operation, including a neutral conductor, but by convention, not a PEN³⁾ conductor or PEM⁴⁾ conductor or PEL⁵⁾ conductor (see **IEV 826-12-08**)

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

Notes ³⁾ A PEN conductor is a conductor combining the functions of both a protective earthing conductor (protective conductor) and a neutral conductor (see **IEV 195-02-12**).

⁴⁾ A PEM conductor is a conductor combining the functions of both a protective earthing conductor and a midpoint conductor (see **IEV 195-02-13**).

⁵⁾ A PEL conductor is a conductor combining the functions of both a protective earthing conductor and a line conductor (see **IEV 195-02-14**).

3.44 machine actuator

power mechanism used to effect motion of the hoisting machine

3.45 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 does not refer only to electrical components.

3.46 manually controlled hoisting machine

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

3.47 marking

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

3.48 neutral conductor

conductor electrically connected to the neutral point and capable of contributing to the distribution of electrical energy (expressed by symbol “N”) (see **IEV 826-14-07**)

3.49 obstacle

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

3.50 overcurrent

electric current exceeding the rated electric current (see **IEV 826-11-14**)

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 1 “Overload” should not be used as a synonym for “overcurrent”.

NOTE 2 In hoisting machines, the term “overload” is also used for mechanical overload, which may or may not cause an electrical overload.

3.52 plug/socket combination

component and 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 conform to **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 **IEC 60320-1**.

3.53 power circuit

circuit that supplies power from the supply network to units of equipment and to transformers supplying control circuits

3.54 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.

3.55 protective bonding circuit

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

3.56 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 (symbol: PE)
- (IEV 826-13-12, modified)

3.57 redundancy

application of more than one (at least two) 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

3.58 reference designation

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

NOTE : The term “reference designation” as used in this Standard is equivalent to the same term defined in **JIS C 0452-1**.

3.59 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)

3.60 safeguard

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

3.61 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**)

3.62 safety-related control function, safety-related control circuit

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

3.63 servicing level

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

3.64 short-circuit current

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

3.65 (electrically) skilled person

person with relevant education and experience to enable him or her to perceive risks and to avoid hazards which electricity can create (see **IEV 826-18-01**)

3.66 supplier

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

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

3.67 switching device

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

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

3.68 terminal

part of an equipment or a component to which a conductor is attached, providing a re-usable connection (**IEV 442-06-05**, modified)

3.69 uncontrolled stop

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

NOTE : This definition does not imply any particular state of other (for example, non-electrical) stopping devices, for example, mechanical or hydraulic brakes that are outside the scope of this Standard.

3.70 user

entity which utilizes the hoisting machine and its associated electrical equipment

4 General requirements

4.1 General considerations

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

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

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

- failures or faults in the electrical equipment resulting in the possibility of electric shock or fire of electrical origin;
- failures or faults in control circuits (or components and devices associated with those circuits) resulting in the malfunctioning of the hoisting machine;
- disturbances or disruptions in power sources as well as failures or faults in the power circuits resulting in the malfunctioning of the hoisting machine;
- loss of continuity of circuits that 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 hoisting machine;
- 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.

In accordance with the hierarchy of protective measures described in **JIS B 9700-1** and **JIS B 9700-2**, the required risk reduction is achieved by measures implemented by the supplier at the design stage and further measures implemented by the user.

The design and development process shall identify hazards and the risks arising from them. For those hazards that cannot be removed and/or those risks that cannot be sufficiently reduced by inherently safe design measures, other protective measures such as safeguarding shall be provided to reduce the risk. Additional means (for example, means such as flashing beacons, warning notices or signs to raise awareness of the risks) shall be provided where further risk reduction is necessary. In addition, working procedures that reduce risk may be necessary.

The use of the inquiry form as shown in Annex B of this Standard is recommended to facilitate an agreement between the user and the supplier(s) on basic conditions and additional user specifications related to the electrical equipment. Those additional specifications are to

- provide additional features that are dependent on the type of hoisting machine (or group of hoisting machines) and the application;
- facilitate maintenance and repair;
- advance the reliability and ease of operation.

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

4.2 Selection of equipment (apparatus)

4.2.1 General

Electrical components and devices used for hoisting machines shall be suitable for their intended use and shall conform to relevant JIS or IEC standards.

4.2.2 Selection of power contactors

The contactors with their associated short-circuit protective devices shall have type “2” coordination in accordance with **JIS C 8201-4-1**, **8.2.5.1**.

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

NOTE : Contactors directly controlling motions and demanding a great number of contactor operations should have a mechanical life of at least 3 million operating cycles.

4.2.3 Electrical equipment in compliance with the related standard series

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

NOTE : **IEC 60439** series specifies the requirements for equipment applicable to a wide range of applications of low voltage switch-gear or control gear assemblies.

4.3 Electrical supply

4.3.1 General

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

- as specified in **4.3.2** or **4.3.3**;
- as otherwise specified by the user (see Annex B);
- as specified by the supplier in the case of a special source of supply such as an on-board generator in **4.3.4**.

4.3.2 AC supplies

Voltage: Steady-state voltage: 0.9 ... 1.1 of nominal voltage

NOTE 1 For certain applications (for example, large container cranes) and by agreement with the user who prepares the power supply, the voltage range may be reduced to 0.95 ... 1.05 of the nominal voltage at the point of supply (i.e., at the crane-supply-switch; see figure 3).

Frequency: 0.99 ... 1.01 of nominal frequency continuously
0.98 ... 1.02 short time

NOTE 2 The short time value may be specified by the user (see Annex B).

Harmonics: Harmonic distortion not to exceed 10 % of the total r.m.s. voltage between live conductors for the sum of the second to fifth harmonic. An additional 2 % of the total r.m.s. voltage between live conductors for the sum of the sixth to 30th harmonic is permissible.

Voltage unbalance: Neither the voltage of the negative sequence component nor the voltage of the zero sequence component in three-phase supplies shall exceed 2 % of the positive sequence component.

Voltage interruption: Supply interrupted or at zero voltage for not more than 3 ms at any random time in the supply cycle. There shall be more than 1 s between successive interruptions.

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

NOTE 4 The crane-switch can operate very frequently. All the components (for example, charging circuitries) need to be selected to allow foreseen switching frequency including the use in commissioning phase.

Voltage dips: Voltage dips shall not exceed 20 % of the peak voltage of the supply for more than one cycle. There shall be more than 1 s between successive dips.

4.3.3 DC supplies

From batteries:

Voltage: 0.85 ... 1.15 of nominal voltage
0.7 ... 1.2 of nominal voltage in the case of battery-operated vehicles

Voltage interruption: not exceeding 5 ms

From covering equipment:

Voltage: 0.9 ... 1.1 of nominal voltage

Voltage interruption: Not exceeding 20 ms. There shall be more than 1 s between successive interruptions.

Ripple (peak-to-peak): Not exceeding 0.15 of nominal voltage.

NOTE : The specification value in **IEC Guide 106**, 500 ms, is changed to 20 ms to ensure proper operation of electronic equipment.

4.3.4 On-board power supply

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

- the supply voltage is not within 0.85 ... 1.1 of nominal voltage;
- the frequency is not within 0.95 ... 1.05 of nominal frequency.

4.4 Physical environment and operating conditions

4.4.1 General

The electrical equipment shall be suitable for the physical environment and operating conditions of its intended use. The requirements of **4.4.2** to **4.4.8** cover the physical environment and operating conditions of the majority of hoisting machines. When special conditions apply or the limits specified are exceeded, an agreement between user and supplier (see **4.1**) is recommended (see Annex B).

4.4.2 Electromagnetic compatibility (EMC)

The equipment shall not generate electromagnetic disturbances above levels that are appropriate for its intended operating environment. In addition, the equipment shall have a level of immunity to electromagnetic disturbances so that it can function in its intended 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 exist (for example, **JIS B 9704-1**, **IEC 61800-3**, **JIS C 8201-5-2**), they take precedence over generic standards.

Measures to limit the generation of electromagnetic disturbances, i.e., conducted and radiated emissions include

- power supply filtering;
- cable shielding;
- enclosures designed to minimize RF radiation;
- RF suppression techniques.

Measures to enhance the immunity of the equipment against conducted and radiated RF disturbance include

- design of functional bonding system taking into account the following:
 - connection of sensitive electrical circuits to the chassis. Such terminations should be marked or labelled with the symbol **IEC 60417-5020**:



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



- separation of sensitive circuits from disturbance sources;
- enclosures designed to minimize RF transmission;
- EMC wiring practices:
 - using twisted conductors to reduce the effect of differential mode disturbances;
 - keeping sufficient distance between conductors emitting disturbances and conductors of sensitive circuits;
 - using cable orientation as close to 90° as possible when cables cross;
 - running the conductors as close as possible to the ground plane;
 - using electrostatic screens and/or electromagnetic shields with a low RF impedance termination.

4.4.3 Ambient air temperature

Electrical equipment shall be capable of operating correctly in the intended ambient air temperature. The minimum requirement for all electrical equipment is correct operation between air temperatures of 0 °C and +40 °C. For very hot environments (for example, hot climates, steel mills, paper mills) and for cold environments, additional measures are recommended (see Annex B).

4.4.4 Humidity

The electrical equipment shall be capable of operating correctly when the relative humidity does not exceed 50 % at a maximum ambient temperature of 40 °C. Higher relative humidity is permitted at lower temperatures (for example, 90 % at 20 °C).

Harmful effects of occasional condensation shall be avoided by proper design of the equipment or, where 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 1 000 m above mean sea-level. A special agreement can be necessary between the supplier and the user (e.g. the agreement on the correct operation at altitudes of 1 000 m or higher above the sea-level) (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, dust, acids, corrosive gases, salts) that can be present in the physical environment in which the electrical equipment is to be installed (see Annex B).

4.4.7 Ionizing and non-ionizing radiation

When equipment is subject to radiation (for example, microwave, ultraviolet, lasers, X-rays), additional measures shall be taken to avoid malfunctioning of the equipment and accelerated deterioration of the insulation. A special agreement is recommended between the supplier and the user (see Annex B).

4.4.8 Vibration, shock, and bump

Undesirable effects of vibration, shock and bump (including those generated by the hoisting machine and its associated equipment and those created by the physical environment) shall be avoided by the selection of suitable equipment, by mounting it away from sources of vibration, or by provision of anti-vibration mountings. A special agreement is recommended between the supplier and the user (see Annex B).

4.5 Transportation and storage

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

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

4.6 Provisions for handling

Heavy and bulky electrical equipment that has to be removed from the hoisting machine for transport, or that is independent of the hoisting machine, shall be provided

with suitable means for handling (e.g. hanging bolts) by cranes or similar equipment (see also **13.4.6**).

4.7 Installation

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

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

5.1 Incoming supply conductor terminations

It is recommended that, where practicable, the electrical equipment of a hoisting machine should be connected to a single power supply. Where it is necessary to use another supply for certain parts of the equipment (for example, electronic circuits, electromagnetic clutches), that supply should be derived, as far as is possible, from devices (for example, transformers, converters) forming part of the electrical equipment of the hoisting machine. For large complex hoisting machines, there may be a need for more than one incoming supply (see **5.3.5.1**).

Unless a plug [see **5.3.2 e**)] is provided with the hoisting machine for the connection to the supply, it is recommended that the supply conductors are terminated at the crane-supply-switch. When that is not practicable, separate terminations shall be provided. Where a neutral conductor is used, it shall be clearly indicated in the technical documentation of the hoisting machine, such as in the installation diagram and in the circuit diagram, and a separate insulated terminal, labelled N, shall be provided for the neutral conductor (see also Annex B).

There shall be no connection between the neutral conductor and the protective bonding circuit inside the electrical equipment, nor shall a combined PEN terminal be used.

Exception: A connection may be made between the N terminal and the PE terminal at the point of supply (see figure 3) to the hoisting machine for TN-C systems⁶⁾ provided they are in accordance with **12.7.2**.

Note ⁶⁾ The TN-C system is one of earthing systems of power supplies, and in the TN-C systems a PEN conductor serves as both a PE conductor and an N conductor. In the commercial power supplies in Japan, the TT system is used and the TN system is not used. For the earthing systems of power supplies, there is a description in Article 272 of the "Interpretation of technical standards on electric equipment", in the document published by the Ministry of Economy, Trade and Industry.

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

5.2 PE 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 (see **8.2.1**) for connection of the hoisting machine to the external protective earthing system or to the external protective conductor, depending upon the supply distribution system (normally TT system in Japan) and in accordance with the relevant installation standards.

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

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

Unit: mm²

Cross-sectional area of phase conductors supplying the equipment S	Minimum cross-sectional area of the external protective copper conductor S_p
$S \leq 16$	S
$16 < S \leq 35$	16
$S > 35$	$S/2$

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

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

5.3 Supply disconnecting and switching devices

5.3.1 General

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

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

(See also figure 3.)

5.3.2 Type

The supply disconnecting and switching devices can be one of the following types:

- a) a switch-disconnector, with or without fuses, in accordance with **JIS C 8201-3**, utilization category AC-23B or DC-23B;
- b) a disconnector, with or without fuses, in accordance with **JIS C 8201-3**, that has an auxiliary contact that in all cases causes switching devices to break the load circuit before the opening of the main contacts of the disconnector;
- c) a circuit-breaker suitable for isolation in accordance with **JIS C 8201-2-1** or **JIS C 8201-2-2**;
- d) any other switching device in accordance with a **JIS** or an **IEC** product standard for that device and which meets the isolation requirements of **JIS C 8201-1** as well as a utilization category defined in the product standard as appropriate for on-load switching of motors or other inductive loads;
- e) a plug/socket combination for a flexible cable supply.

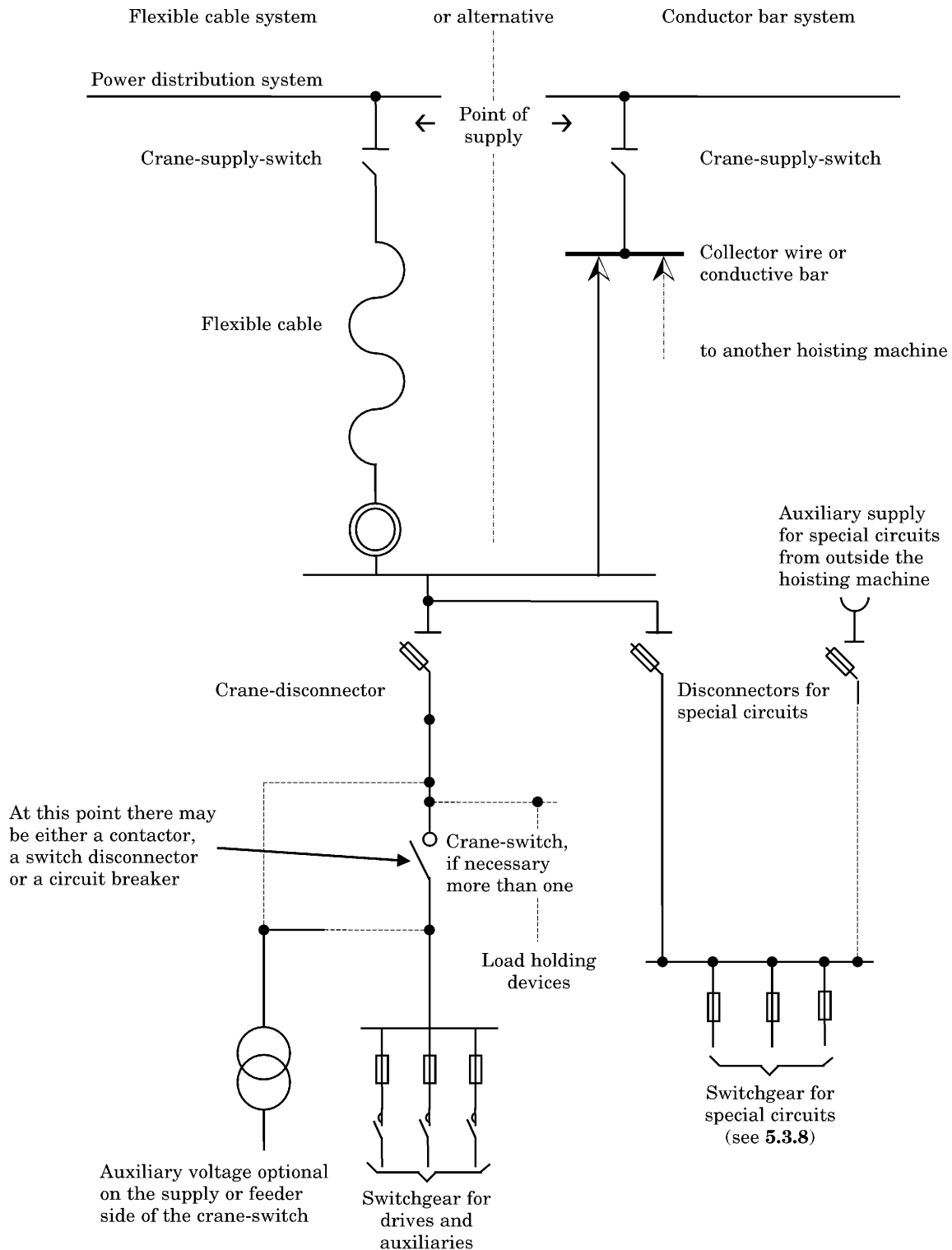


Figure 3 Examples of electrical supply systems

5.3.3 Requirements

When the supply disconnecting and switching device is one of the types specified in **5.3.2 a)** to **d)** it shall fulfil all of the following requirements.

- Isolate the electrical equipment from the supply and have one OFF (isolated) and one ON position marked with “○” and “I” (symbol **IEC 60417-5008** and **IEC 60417-5007**, see **10.2.2**).
- Have a visible contact gap or a position indicator which cannot indicate OFF (isolated) until all contacts are actually open and the requirements for the isolating function have been satisfied.
- Have an external operating means (for example, a handle)

Exception: power-operated switchgear need not be operable from outside the enclosure where there are other means to open it.

Where the external operating means is not intended for emergency operations, it is recommended that it be coloured BLACK or GREY (see **10.7.4** and **10.8.4**).

- Be provided with a means permitting it to be locked in the OFF (isolated) position (for example, by padlocks). When so locked, remote as well as local closing shall be prevented.
- Disconnect all live conductors of its power supply circuit. However, for TN-S supply systems⁷⁾, the neutral conductor may or may not be disconnected.

Note ⁷⁾ The TN-S system refers to an earthing system in which a PE conductor and an N conductor (neutral conductor) are separated in the TN system. The TN-S system is not used for the commercial power supplies in Japan.

In any earthing system, PE conductor and PEN conductor should not be disconnected.

- 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.

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

When the supply disconnecting device is a plug/socket combination, it shall fulfil the following requirements.

- Have the switching capability, or be interlocked with a switching device that has a breaking capacity, sufficient to interrupt the current of the largest motor when stalled together with the sum of the normal running currents of all other motors and/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.

- Subclause **13.4.5**.

NOTE : A suitably rated plug and socket-outlet, cable coupler, or appliance coupler, in accordance with **JIS C 8285** can fulfil these requirements.

Where the supply disconnecting device is a plug/socket combination, a switching device with an appropriate utilization category shall be provided for switching the

machine on and off. This can be achieved by the use of the interlocked switching device described above.

5.3.4 Operating means

The operating means (for example, a handle) of the supply disconnecting and switching device shall be easily accessible and located between 0.6 m and 1.9 m above the servicing level. An upper limit of 1.7 m is recommended.

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

5.3.5 Crane-supply-switch

5.3.5.1 General

NOTE : This subclause does not apply to hoisting machines having on-board power supplies and without an alternative power supply from the outside.

Crane-supply-switches shall be provided

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

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

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

5.3.5.2 Type

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

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

5.3.5.3 Requirements

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

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

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

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

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

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

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

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

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

5.3.6 Crane-disconnector

5.3.6.1 General

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

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

NOTE 1 A floor-controlled hoisting machine is operated from a suspended pendant control station, a remote fixed control station, or a portable control station.

- A crane-disconnector is not necessary in cases where the voltage can be reduced to, and maintained at, zero by other means (for example, locking off a diesel generator fuel supply or starter mechanism, etc.).
- On hoisting machines with power supplied at voltages of more than 1 kV a.c. and having one or more transformers installed on the hoisting machine, supplying a low-voltage system, one or more crane-disconnectors are provided on the secondary side of each transformer to isolate the low-voltage sections (see also **5.5**) and no crane-disconnectors are required on the primary side. Circuits associated with each crane-disconnector shall be clearly identifiable, for example, by

- separation; or
- barriers; or
- marking and labelling.

NOTE 2 Preference should be given to the disconnection of a hoisting machine using only one crane-disconnector.

5.3.6.2 Type

Where provisions are made against both inadvertent and unauthorized opening, the crane-disconnector shall, as a minimum, conform to the requirements for disconnectors given in **JIS C 8201-3**. Otherwise, it shall meet the requirements for switch-disconnectors given in **JIS C 8201-3**. The actuator (control handle) of the crane-disconnector shall conform to the requirements of **5.3.4**.

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

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

5.3.6.3 Requirements

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

5.3.7 Crane-switch

5.3.7.1 General

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

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

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

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

5.3.7.2 Type

The crane-switch shall as a minimum meet the requirements for switches given in **JIS C 8201-3**. This requirement can be fulfilled by one of the devices specified in **5.3.2 a)** or **c)**. Contactors selected in accordance with **4.2.2** and used in combination with disconnecting devices may also be used.

5.3.7.3 Requirements

The requirements of **5.3.3** and **5.3.4** shall apply as appropriate.

5.3.8 Special circuits

Special circuits, which need to be operational during repair and maintenance work, shall be supplied from the supply side of the crane-disconnector specified in **5.3.6** (but not through the crane-disconnector) using a dedicated disconnector (see figure 3) that conforms to the requirements of **5.6**.

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

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

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

Special circuits shall be identifiable by

- permanent warning label(s) in accordance with **16.1** placed in proximity to the crane-disconnector;
- a corresponding statement included in the maintenance manual; and one or more of the following shall apply:
 - a) a permanent warning label in accordance with **16.1** is placed in proximity to each special circuit, or
 - b) the special circuit shall be separated from other circuits, or
 - c) 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 (for example, where, during maintenance, a start-up of the hoisting machine or part of it can create a hazard). The crane-disconnector (see **5.3.6**) fulfils that function for the complete hoisting machine. Where it is necessary to work on individual parts of a hoisting machine, additional devices for switching off shall be provided for each part requiring separate disconnection.

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

NOTE 1 This Standard does not address all provisions for prevention of unexpected start up. See **JIS B 9714**.

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

NOTE 2 Further information on the location and actuation of devices such as those used for the prevention of unexpected start-up is provided in **JIS B 9714**.

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

- devices described in **5.3.2**;
- disconnectors, withdrawable fuse links and withdrawable links only if located in an enclosed electrical operating area (see **3.26**).

Devices that do not fulfil the isolation function (for example, a contactor switched off by a control circuit) may only be provided where intended to be used for situations that include

- inspections;
- adjustments;
- work on the electrical equipment where
 - there is no hazard arising from electric shock (see clause **6**) and burn;
 - the switching-off means remains effective throughout the work;
 - the work is of a minor nature (for example, replacement of plug-in devices without disturbing existing wiring).

NOTE 3 The selection of a device should take into account, for example, information derived from the risk assessment, intended use and foreseeable misuse of the device. 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)**].

NOTE 4 The definition and explanation of unexpected start-ups are given also in **3.29** of **JIS B 9700-1**. The start-up made by an operator who pushes the start switch of a control panel without knowing that a maintenance person is performing maintenance of the machine concerned is an unexpected start-up from the standpoint of the maintenance person. The device for switching off for prevention of an unexpected start-up is for making a machine unable to start up while this is opened. For example, if this is opened, during the maintenance work, a machine does not start up even if someone pushes the start switch accidentally.

NOTE 5 The provision in **5.4** does not require all of the hoisting machines to be equipped with the device for switching off for preventing an unexpected start-up in addition to the device for disconnecting incoming supply specified in **5.1**. Depending on hoisting machines (electrical equipment), an unexpected start-up may be prevented by opening the device for disconnecting incoming supply.

5.5 Devices for disconnecting electrical equipment

NOTE 1 The “electrical equipment” specified in **5.5** is not electrical equipment as an aggregate containing all electrical devices of the machine, but individual parts such as each power circuit, a transformer, a motor and a control circuit (see **3.28**). Although it is basically assumed that the “device for disconnecting electrical equipment” required here is provided in addition to the supply disconnecting device specified in **5.3**, in simple machines (electrical equipment), the supply disconnecting device may fulfil this function. The necessity of an independent device for disconnection is dependent on the results of risk assessment.

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

- appropriate and convenient for their intended use;
- suitably placed;
- readily identifiable as to which part(s) or circuit(s) of the equipment is served.

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

The crane-disconnector (see **5.3.6**) may, in some cases, fulfil that function. However, where it is necessary to work on individual parts of the electrical equipment of a hoisting machine, or on one of a number of hoisting machines fed by a common conductor bar, conductor wire or inductive power supply system, a disconnecting device shall be provided for each part, or for each hoisting machine, requiring separate isolation.

In addition to the crane-disconnector, the following devices that fulfil the isolation function may be provided for this purpose:

- devices described in **5.3.2**;
- disconnectors, withdrawable fuse links and withdrawable links only if located in an electrical operating area (see **3.22**) and relevant information is provided with the electrical equipment [see **17.2 b) 9)** and **b) 12)**].

NOTE 2 Where protection against electric shock is provided in accordance with **6.2.2 c)**, withdrawable fuse links or withdrawable links for this purpose are intended for use by skilled or instructed persons.

5.6 Protection against unauthorized, inadvertent and/or mistaken connection

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

Where a non-lockable disconnecting device is used within an enclosed electrical operating area (for example, withdrawable fuse-links, withdrawable links) other means of protection against reconnection (for example, warning labels in accordance with **16.1**) may be provided.

However, when a plug/socket combination in accordance with **5.3.2 e)** is so positioned that it can be kept under the immediate supervision of the person carrying out the work so that no unintended connection is performed, 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

- direct contact (see **6.2** and **6.4**);
- indirect contact (see **6.3** and **6.4**).

The measures for this protection given in **6.2**, **6.3**, and, for PELV, in **6.4**, are a recommended selection from **JIS C 60364-4-41**. Where those recommended measures are not practicable, for example, due to the physical or operational conditions, other measures from **JIS C 60364-4-41** may be used.

NOTE : In **JIS C 60364-4-41:2010**, the terms “basic protection” and “fault protection” are used instead of “protection against direct contact” and “protection against indirect contact”, which are used in this Standard.

6.2 Protection against direct contact

6.2.1 General

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

Exception: Where those measures are not appropriate, other measures for protection against direct contact (for example, by using barriers, by placing out of reach, using obstacles, using construction 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 places open to all persons, which can include 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 be applied.

6.2.2 Protection by enclosures

Live parts shall be located inside enclosures that conform to the relevant requirements of clauses **4**, **11**, and **14** and that provide protection against direct contact of at least IP2X or IPXXB (see **JIS C 0920**).

Where the top surfaces of the enclosure are readily accessible, the minimum degree of protection against direct contact provided by the top surfaces shall be IP4X or IPXXD.

Opening an enclosure (i.e., opening doors, lids, covers, and the like) shall be possible only under one of the following conditions.

- a) The use of a key or tool is necessary for access. For enclosed electrical operating areas, see **JIS C 60364-4-41** or **IEC 60439-1**, as appropriate.

NOTE 1 The use of a key or tool is intended to restrict access to skilled or instructed persons [see **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, shall be protected against direct contact to at least IP2X or IPXXB. Other live parts on the inside of doors shall be protected against direct contact to at least IP1X or IPXXA.

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

This may be accomplished by interlocking the door with a disconnecting device (for example, the crane-disconnector) so that the door can only be opened when the disconnecting device is open and so that the disconnecting device can only be closed when the door is closed.

Exception: A special device or tool (see NOTE 2) as prescribed by the supplier can be used to defeat the interlock provided that

- it is possible at all times while the interlock is defeated to open the disconnecting device and lock the disconnecting device in the OFF (isolated) position or otherwise prevent unauthorized closure of the disconnecting device;
- upon closing the door, the interlock is automatically restored (By this, when the door is opened the next time, disconnection is automatically carried out.);
- all live parts, that are likely to be touched when resetting or adjusting devices intended for such operations while the equipment is still connected, are protected against direct contact to at least IP2X or IPXXB and other live parts on the inside of doors are protected against direct contact to at least IP1X or IPXXA;
- relevant information is provided with the electrical equipment [see **17.2 b) 9)** and **b) 12)**].

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

Means shall be provided to restrict access to live parts behind doors not directly interlocked with the disconnecting means to skilled or instructed persons [see **17.2 b) 12)**].

All parts that are still live after switching off the disconnecting device(s) shall be protected against direct contact to at least IP2X or IPXXB (see **JIS C 0920**). 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).

Excepted from this requirement for marking are

- parts that can be live only because of connection to interlocking circuits and that are distinguished by colour as potentially live in accordance with **13.2.4**;
- the supply terminals of the crane-supply-switch and the crane-disconnector when they are mounted alone in a separate enclosure.

- c) Opening without the use of a key or a tool and without disconnection of live parts shall be possible only when all live parts are protected against direct contact to at least IP2X or IPXXB (see **JIS C 0920**). Where barriers provide this protection, either they shall require a tool for their removal or all live parts protected by them shall be automatically disconnected when the barrier is removed.

NOTE 3 Where protection against direct contact is achieved in accordance with **6.2.2 c)**, and a hazard can be caused by manual actuation of devices (for example, manual closing of contractors or relays), such actuation should be prevented by barriers or obstacles that require a key or a tool for their removal.

6.2.3 Protection by insulation of live parts

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

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

6.2.4 Protection against residual voltages

Live parts having a residual voltage greater than 60 V after the supply has been disconnected shall be discharged to 60 V or less within a time period of 5 s after disconnection of the supply voltage provided that this rate of discharge does not interfere with the proper functioning of the equipment. Exempted from this requirement are components having a stored charge of 60 μC or less. Where this specified rate of discharge would interfere with the proper functioning of the equipment, a durable warning notice drawing attention to the hazard and stating the delay required before the enclosure may be opened shall be displayed at an easily visible location on or immediately adjacent to the enclosure containing the capacitances.

In the case of plugs or similar devices, the withdrawal of which results in the exposure of conductors (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 (for example, in the case of removable collectors on conductor wires, conductor bars, or slip-ring assemblies, see **12.7.4**), additional switching devices for protection against electric shock or an appropriate warning device (for example, a warning notice in accordance with **16.1**) shall be applied.

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

6.2.5 Protection by barriers

For protection by barriers, **JIS C 60364-4-41** shall apply.

6.2.6 Protection by placing out of reach or protection by obstacles

For protection by placing out of reach, **B.3** of **JIS C 60364-4-41** shall apply. For protection by obstacles, **B.2** of **JIS C 60364-4-41** shall apply.

For conductor wire systems or 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 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 equipment (classification according to electric shock protection) and protective provisions see **JIS C 0365**.

6.3.2 Prevention of the occurrence of a touch voltage

6.3.2.1 General

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

- provision of Class II equipment or by equivalent insulation;
- electrical separation.

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

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

This protection is provided by one or more of the following:

- Class II electrical devices or apparatus (double insulation, reinforced insulation or by equivalent insulation in accordance with **JIS C 0365**);
- switchgear and controlgear assemblies having total insulation in accordance with **IEC 60439-1**;
- supplementary or reinforced insulation in accordance with clause **412** 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 parts that can be energized by a fault in the basic insulation of the live parts of that circuit.

For this type of protection, the requirements of clause **413** and **C.3** of **JIS C 60364-4-41** apply.

6.3.3 Protection by automatic disconnection of supply

This measure consists of the interruption of one or more of the line conductors by the automatic operation of a protective device in case of a fault. This interruption shall occur within a sufficiently short time to limit the duration of a touch voltage to a time within which the touch voltage is not hazardous. Maximum allowable disconnection times applicable to the TN system are given in Annex A, and those applicable to the TT system (mainly applied in Japan) are given in Annex JA.

This measure necessitates coordination between

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

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

This protective measure comprises both

- protective bonding of exposed conductive parts (see **8.2.3**);
- and either:
 - a) overcurrent protective devices for the automatic disconnection of the supply on detection of an insulation fault in TN systems⁸⁾; or

Note ⁸⁾ For the TN system (TN power system), one point of the power supply side is directly earthed and the exposed conductive part of equipment (hoisting machine in this Standard) is connected to the point with a protective conductor (see **JIS C 60364-1**).

- TN-S system: A protective conductor is separated over the whole system.
- TN-C system: One conductor serves as both a neutral conductor and a protective conductor over the whole system. The TN system is used in Europe and North America and is not used for the commercial power supplies in Japan.

- 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 systems⁹⁾; or

NOTE 1 In the case of the TT system, a prior agreement should be made between the user and the supplier of electrical equipment on where the earth leakage breaker is to be installed (see Annex B). When an earth leakage breaker is not installed in the power source supply circuit to electrical equipment (outside electrical equipment), or when an earth leakage breaker installed does not satisfy the provision of Annex JA, it becomes necessary to install a suitable