

JIS

JAPANESE INDUSTRIAL STANDARD

**Electrical Equipment
of Machine Tools**

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the original Standard in Japanese is to be final authority.



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JAPANESE INDUSTRIAL STANDARD

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Electrical Equipment of Machine Tools

B 6015-1989

1. Scope

This Japanese Industrial Standard specifies electrical equipment of machine tools which operates from a.c. power supplies with a voltage not exceeding 600 V and a frequency 50 Hz or 60 Hz.

- Remarks 1. This Standard applies to the electrical equipment of automatic machines for assembling, transfer and measurement associated with machine tools.
2. This Standard provides detailed specifications relating to the electrical equipment of machine tools so as to promote the following:
- (1) Safety of personal and machine tools.
 - (2) Minimization of production interruption due to trouble of electrical equipment.
 - (3) Easy maintenance.
 - (4) Long life of machine tools.

2. Definitions

For the purpose of this Standard the following definitions apply:

- (1) machine tool In the narrow sense of the word, a machine which mainly forms metal workpiece into a prescribed shape by removing unnecessary portions by cutting or grinding. However, machines in which the workpiece is held by the hands or fixed by a magnetic stand are excluded. It is sometimes called metal cutting machine tool when the narrow sense is especially enhanced [refer to JIS B 0105].
- (2) electrical equipment The generic name of all electric machinery and apparatus composing a part of a machine tool including electromagnetic and electronic machinery and apparatus.
- (3) electronic equipment The equipment mainly composed of electronic components. For example, numerical control equipment, sequencers and servo amplifiers.
- (4) controlgear A device in which apparatus for control, measurement, protection, adjustment, etc. are built-in and connected electrically and mechanically each other.

- (5) control box A box which accommodates power supply disconnecting switch, electromagnetic switches, relays, etc.
- (6) enclosure Generic name of housing providing protection for persons against direct contact with live parts contained therein and protection against certain defined external influences for the electrical equipment therein.
- (7) duct A structure of gutter or pipe shape used for holding and protecting electrical conductors.
- (8) conduct A tubular duct having rigid or flexible walls made of metal or insulating material.
- (9) live part⁽¹⁾ Any conductor or conductive part which is at a voltage in normal use.

Note (1) Live parts also include the neutral conductor and conductive parts connected with it.

- (10) exposed conductive part Conductive part which can readily be touched and which is not a live part but which may become alive under fault conditions in electrical equipment for machine tools.
- (11) protective earthing conductor A wire used for connecting exposed conductive part with one of the following parts and then with the earth:
 - (a) other exposed conductive parts
 - (b) conductive parts of equipment other than electrical equipment
 - (c) Earth electrodes, or an earthed conductor
 - (d) Earthed live parts (including neutral wire)
- (12) electrical operator A person who has mastered electrical knowledge and works for handling of electrical equipment of machine tools as his occupation.
- (13) protective circuit The whole of the protective conductors and conductive parts participating in protection against the consequences of earth-faults.
- (14) power circuit The circuit for supplying power from the supply network or generator to motors and other apparatus.
- (15) control circuit The circuit used for operational control and protection of the machine tool.
- (16) signalling circuit The circuit used for supplying signals to such components as indicators, pointers and warnings.
- (17) electronic component Constituent part of the electronic equipment. For example, resistors, capacitors, transistors and integrated circuit.

- (18) switching device A device which opens and closes the electric circuit(s).
- (19) power supply disconnecting device A manually or electrically operated switching device used for isolating the circuit of equipment or machinery and apparatus from the power supply network.
- (20) control device The device connected into the control circuit and used for controlling the operation of the machine, such as position sensor, manual control switch, relay and electromagnetic valve.
- (21) operating device A manually operated device for controlling the operation of the machine tool such as push button switch and selector switch.
- (22) molded-case circuit-breaker A device composed of a switching mechanism and a tripping device assembled in a housing of insulating material as an integral unit, which allows manual switching of the electric circuit under normal conditions and interrupts the circuit automatically at the time of overload or short circuit without suffering any damage.
- (23) overcurrent breaker A device which has the function to interrupt an overcurrent or short-circuit current automatically such as molded-case circuit breakers, fuses and air circuit-breakers.
- (24) branched circuit The circuit from the branch point on the main line to the load via branch overcurrent breaker.
- (25) electric line Whole or a part of circuit through which the current is passed under normal service conditions.
- (26) wire The generic name of insulated wire, bare wire, cord cable, etc.
- (27) voltage to earth The voltage between the wire and the earth in an earthed electric line, and the voltage between lines in a non-earthed electric line.
- (28) actuator The part of the actuating system of a control device to which an external actuating force is applied. For example, a handle, knob, push-button, roller, plunger, etc.
- (29) item designation The letter code used for identifying an item of component described in the wiring diagram and detail component list. This is also used in the nameplate.
- (30) servicing level The plane on which the maintenance person stands at the time of maintenance or repair of electric equipment.
- (31) class II insulation electric machinery and apparatus (appliance) Electric machinery and apparatus in which double insulation or reinforced insulation is used or combination of double insulation and reinforced insulation is used all over the appliance and which are not earthed.
- (32) total insulation The insulation which completely covers whole the appliance.

- (33) basic insulation The basic insulation necessary for the function of the appliance which provides basic protection against electric shock.
- (34) supplementary insulation An independent insulation applied in addition to the basic insulation, in order to ensure protection against electric shock in the event of a failure of the basic insulation.
- (35) double insulation The insulation comprising both basic insulation and supplementary insulation.
- (36) reinforced insulation The reinforced basic insulation system which is at least equivalent to the double insulation in electrical and mechanical performances and applicable to only the case that application of double insulation is difficult.

3. Conditions for Running, Transportation and Storage of Electric Equipment

3.1 Ambient Temperature The electric equipment shall operate correctly at the ambient temperature given below. If use of equipment at an ambient temperature other than this temperature range is anticipated the specification shall be separately agreed between the user and manufacturer.

Ambient temperature	0 to 40°C
Average temperature over a period of 24 h	35°C or below

Remark: When additional temperature rise due to the screen and heat producing body surrounding the location of electric equipment is anticipated, the manufacturer of the machine tool shall give the user such information that adequate precaution is necessary.

3.2 Altitude The electrical equipment shall operate correctly at altitudes up to and including 2000 m. However, for electronic equipment the altitudes shall be up to and including 1000 m.

3.3 Atmospheric Conditions The electrical equipment shall operate correctly with a relative humidity not exceeding 50 %⁽²⁾ at 40°C and 90 % at 20°C. If higher humidities may occur or abnormal amounts of dust, acids, corrosive gases and salt may be present, a special agreement between manufacturer and user is necessary.

Harmful effects of condensation such as rust shall be avoided by proper design of the electrical equipment. If necessary, such additional measures as built-in air conditioner should be considered.

Note (2) Air with a relative humidity of 50 % at 40°C will be condensed if cooled to 28°C.

3.4 Installation and Operation Electrical equipment shall be installed and operated in accordance with the manufacturer's instructions. In case of special circumstances, the user shall inform the manufacturer and shall have a special agreement.

3.5 Transportation and Storage Electrical equipment shall withstand the conditions given below. Suitable means shall be provided to prevent damage from humidity and from vibration.

Ambient temperature -20 to 55°C
For short period not exceeding 24 h 70°C or less

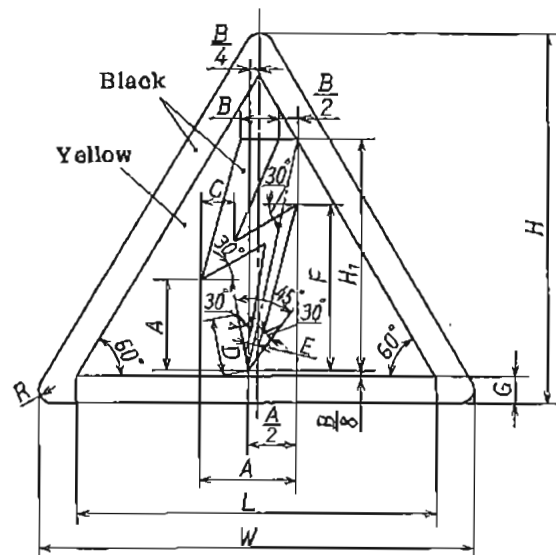
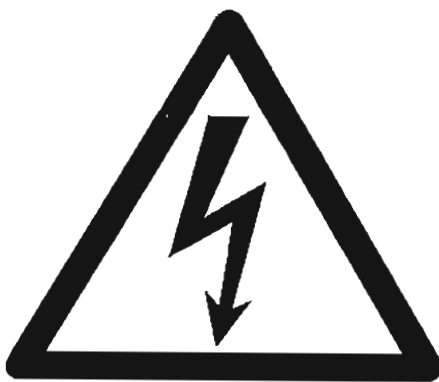
If special means are necessary, proper warnings shall be placed on the shipping container.

4. Warning Signs, Marking, Item Designation and Technical Documentation

4.1 Warning Signs, Marking and Item Designation

4.1.1 Warning Signs on Enclosure All enclosures shall bear the live mark illustrated in Fig. 1.

Fig. 1. Live Mark



Unit: mm

H	L	G	R	W	H ₁	A	B	C	D	E	F
20	18.5	1.6	0.8	(22.9)	12.5	5	2	1.8	3.1	0.7	9
40	37.5	3	1.5	(45.7)	25	10	4	3.5	6.3	1.4	18
80	75	6	3	(91.4)	50	20	8	7	12.5	2.8	36
125	117	9.4	4.7	(142.7)	78	31.3	12.6	10.9	19.5	4.4	56.3
160	150	12	6	(182.8)	100	40	16	14	25	5.6	72

Remark: Numerical values in parentheses in this table are those for informative reference.

4.1.2 Nameplate of Controlgear A nameplate indicating the following specification shall be attached to each controlgear:

- (1) Manufacturer's name
- (2) Serial number or registered number
- (3) Rated voltage (identification of d.c. or a.c.)
- (4) Rated frequency and number of phases
- (5) Rated kVA or rated current

The rated current shown on the nameplate shall be not less than the sum of the rated currents of electrical machinery, apparatus and equipment which may be in operation at the same time under normal conditions of use.

If it is necessary to take a power supply more than the sum of the rated currents into consideration due to the control system, the expected current shall be entered in the nameplate as the rated current.

4.1.3 Marking of Control Device The following information shall be marked on each control device:

- (1) Manufacturer's name or trade mark
- (2) Type of device or its substitute
- (3) Operating voltage (with frequency if a.c.)

The items (1) to (3) shall be marked separately on the coil if the device has removable coils. If the marking is impossible because the device is too small, the items shall be indicated on a diagram or component list.

4.1.4 Marking of Replaceable Components Replaceable components shall be marked in one of the following ways:

- (1) Item designation or symbol
- (2) Manufacturer's name or trade mark, and ratings for components other than those marked as specified in (1).
- (3) If marking is impossible due to small size of component, indication on diagram or component list.

Remark: The item designation shall be as given in Appendix 1.

4.1.5 Marking of Wires, Devices and Terminals The markings which are identical to those on the drawing shall be so attached to the wires, devices and terminals that they will not easily removed, for convenience in such works as maintenance, mounting of component and reassembling. However, electronic equipments are excluded if application of such marking is difficult. The item designation may be used as the marking.

4.1.6 Marking of Operating Device Such operating devices as push button switches and selector switches shall be marked with their function by means of letters or the symbols specified in JIS B 6012.

4.2 Technical Documentation

4.2.1 General The technical documents submitted to the user shall have contents necessary for installation operation maintenance, etc. of electrical equipment. It is desired to attach a set of technical documents to the control box or the like separately.

4.2.2 Contents of Technical Documents The technical documents shall include the contents prescribed below. However, the items (2), (4), (5), (7) and (9) may be omitted if the contents are easily understood in other parts of the technical documents.

- (1) Installation drawing
- (2) Block diagram
- (3) Schematic diagram (circuit diagram)
- (4) Explanation of sequence of operations
- (5) Interconnection diagram or interconnection table
- (6) Parts list
- (7) Maintenance instruction
- (8) Location diagram in a board
- (9) Spare part list

4.2.3 Form of Technical Documents For referencing of the different documents, each of the documents shall carry, as a cross-reference, the reference numbers of all the other documents belonging to one and the same electrical equipment, or all the documents shall be listed with reference number and title in a table of contents and this list shall be appended.

Instructions, drawings, etc. shall be issued in A 4 (210 x 297 mm) specified in JIS P 0138 or a size equal to integer multiple of A 4. A 1 is recommended as the maximum size.

The graphical symbols used on drawings, lists, etc. shall be as specified in Appendix 2.

The identification of components, devices, terminals and conductors shall be the same in all documents and in the electrical equipment.

4.2.4 Contents of Particular Documents

4.2.4.1 Installation Drawing The installation drawing shall include the contents given below which are necessary for the user to install the machine tool (see Informative Reference Fig. 1). However, the items (5) to (7) may be omitted when the interconnection diagram is prepared.

- (1) The data necessary for choosing the type, characteristic, and rated or setting current of the overcurrent protective device to be installed at the power supply side of electrical equipment
- (2) The position, rated current or minimum sectional area of wire of power supply outlet(s) for electrical equipment
- (3) The size, location and purpose of ducts to be provided by the user
- (4) The space necessary for removal or servicing of electrical equipment
- (5) Details of ducts and cable routing
- (6) The position of the control devices placed outside the enclosure(s)

- (7) The position of the connection devices necessary for the re-connection after disassembling

4.2.4.2 Block Diagram The block diagram is a diagram which shows the functional interrelationships of electrical equipment by symbols or simple drawings and by which the operation of the equipment can be understood easily.

4.2.4.3 Schematic Diagram The schematic diagram is a diagram which shows the functioning and circuit connections of the electrical equipment, and by which the operation of the equipment can be understood (see Informative Reference Figs. 2, 3 and 4).

It is recommended that the progression of successive operations should be described from the left to the right or from the top to the bottom for easy reading of the diagram.

The purpose of each circuit on the mechanical operation shall be clearly stated.

- (1) The apparatus shall be shown in the following conditions:
 - (a) Controlgears are de-energized
 - (b) Binary logic elements are in the reset state
- (2) It is recommended that on the diagram the power, control and other circuits are indicated separately.
- (3) For all interconnection terminals, connected together directly and therefore having the same potential, it is recommended that they are designated with the same symbol.
- (4) It is recommended that the symbols for interconnection terminals are distinguished from the symbols for the terminals of the devices.
- (5) It is recommended that a block diagram on which detail input-output relationships and the truth value tables of the elements are indicated is prepared as the schematic diagram of electronic equipment.
- (6) It is recommended that the schematic diagram contains the following items:
 - (a) Polarities
 - (b) Voltage, frequency and number of phases of each power supply
 - (c) Particular characteristics (values of resistance capacitance etc.) operating methods, functioning, settings of certain control devices when these are necessary for explanation of operation of the device.
- (7) When the machine can perform several sequences, the diagram shall be written for each sequence and shall show clearly which sequence it represents.

- (8) The various circuits shall be shown as prescribed below to facilitate the understanding of the maintenance and operation.
- (a) Circuits shall be shown separately on the diagram if they are separate electrically or if they concern different operations.
 - (b) Power circuits shall be shown by one or several lines at right angles to the bus bar.
 - (c) Each of the control circuits shall be shown by one or more lines at right angles to two or more parallel lines.
It is recommended that operating coils are shown near the line to which they are directly connected and which is intended to be earthed, and the control contacts are shown between the coil and the other line.
 - (d) When signalling circuits are supplied separately from control circuits, it is recommended they are shown between two or more parallel lines, at right angles to the latter.
It is recommended that indicator lights and warning units are shown near the line to which they are connected and which is intended to be earthed, and the control contacts are connected to the other line.

4.2.4.4 Description of Sequence of Operation or Sequence Chart In the description of sequence of operation or sequence chart, detailed information shall be given to allow the sequence of operations of the various parts to be understood by reference to the schematic diagram.

All the information shall be given which is necessary for the understanding of the electrical operation in conjunction with the mechanical, hydraulic or pneumatic operations.

If the machine tool can perform several sequences, the description of operation shall explain each of them (see Informative Reference Fig. 5).

4.2.4.5 Interconnection Diagram or Interconnection Chart The interconnection diagram or interconnection chart is a document which shows the relationships of electrical connection between the devices and between the electrical equipment and external networks, and the path of each wire shall be shown if necessary (see Informative Reference Fig. 6 and Informative Reference Table 1).

If it is possible to operate the electrical equipment by two or more kinds of power supply, the method of this change-over shall practically be shown.

The connecting terminals of power supply and protective earth wire shall be indicated.

The specification (number of wires, sectional areas, classification) of wires used for connection of the equipment and devices shall be clearly stated.

If necessary, the path of wire and the position of earthing shall be clearly stated.

4.2.4.6 Parts List The parts list is a list of all electrical components including the necessary data for the ordering of spare parts, and shall include the following matters for each different component:

- (1) The item designation used in the diagram
- (2) The name of part
- (3) General characteristics (output, torque, speed, voltage, current, frequency, degree of protection, insulation class, etc.)
- (4) Manufacturer's name (or abbreviation) and type designation
- (5) The number of identical components in the equipment

This list shall also show the characteristics of special types of cables (sectional area, class, etc.) together with the name of manufacturer (see Informative Reference Table 2).

4.2.4.7 Maintenance Instruction The maintenance instruction is a document which explains the matters relating with maintenance and adjustment and shall include the following explanation:

- (1) Schedule of preventive maintenance
- (2) Matters necessary for replacement work
- (3) Matters necessary for adjustment work

It is recommended that the frequency of replacement of parts subject to wear is mentioned.

4.2.4.8 Location Diagram The location diagram is a document which shows relative position of electrical apparatus in a control box or an enclosure, and it shall show each apparatus with the same item designations used in related diagrams.

This diagram is not necessarily show dimensions.

It shall show the spaces which have been reserved for modification as well as the location of ducts or conduits which are used for the wiring of the controlgear assembly (see Informative Reference Fig. 7).

4.2.4.9 Spare Part List The spare part list shall mention the parts which it is recommended to carry in stock. For the spare parts mentioned in the maintenance instruction, the necessary information for ordering such parts shall be given in this spare part list (see Informative Reference Table 3).

5. General Requirements

5.1 Components and Devices to be Used

5.1.1 Requirements for Components and Devices Electrical components and devices shall be suitable for industrial use. Preference shall be given to components and devices which are obtainable from more than one manufacturer under the same designation and, as far as possible, under the same reference number.

It is recommended not to use special devices or components nor to modify them. If this can not be avoided, for replacement and repair at site, full information shall be given on modification of such special components and devices in the parts list or on the drawings.

5.1.2 Limitations of Use All components and devices shall be used within the limits of voltage, current, temperature, impact, vibration, factory environment, etc. specified by the manufacturer.

5.2 Power Supply The electrical equipment shall be designed for operation from the power supply voltages and frequency specified by the user. It shall operate correctly at voltages within $\pm 10\%$ from the nominal power supply voltage and with frequency deviations up to $\pm 2\%$. If for the warranted accuracy of timer circuits or the like a closer frequency tolerance than $\pm 2\%$ is necessary, this shall be clearly stated by the manufacturer.

The electronic equipment shall operate correctly under the following conditions:

- (1) Voltage interruption of less than 10 ms (power electronics excepted.)
- (2) Voltage drops not exceeding 0.5 s and less than 15 % of the nominal supply voltage
- (3) Voltage impulses not exceeding 1.5 ms and with peak values not exceeding 200 % of the nominal r.m.s. supply voltage between lines
- (4) In the a.c. power supply voltage, the waveform distortion shall not exceed 7 % and the unbalance in line voltages shall not exceed 5 %

Interlocks shall be provided to stop the operations concerned, if electronic equipment is responsible for safety or continuous operation and might malfunction from a voltage interruption of a shorter duration.

5.3 Connection to Power Supply Network The connection to the power supply network shall be as follows:

- (1) It is recommended that the electrical equipment is connected to a single power supply as far as possible. If another voltage is necessary for the electronic equipment, electromagnetic clutches, etc., this other voltage should, as far as possible, be supplied from the converting devices such as transformers and rectifiers accommodated in the electrical equipment.
- (2) A neutral line shall be used only with the agreement of the user. If it is used, this shall be clearly stated in the technical documentation such as the schematic diagram and interconnection diagram. There shall be no connection between the neutral line and the protective earth terminal inside the electric equipment.
- (3) Unless a plug is provided with the machine for connection to the power supply system, it is recommended to connect the wires from the power source directly to the primary terminals of the power supply disconnecting device. If this direct connection to primary terminals is not practicable, wiring shall be made via terminals separately provided.

The main earth terminal shall be provided in the vicinity of the power supply terminals.

If a neutral line is used, a separate insulated terminal shall be provided for the line.

- (4) All terminals for supply connection shall clearly be identified by the following symbols:

(a) Supply a.c. system conductors	Phase 1	L 1
	Phase 2	L 2
	Phase 3	L 3
	Neutral	N
(b) Protective conductor		P E
(c) Earthing conductor		E
(d) Low noise earth conductor		T E

6. Protection

6.1 Protection Against Electric Shock The electrical equipment shall provide protection of persons against electric shock in normal service, at the time of current leak, or due to residual voltage, as given below.

6.1.1 Protection Against Electric Shock in Normal Service This protection is the basic protection and intended to protect persons against dangers of direct contact with live parts. For each circuit or part, the measures given in 6.1.1.1 or 6.1.1.2 shall be employed.

6.1.1.1 Protection by Enclosures Live parts shall be located inside enclosures which comply with the relevant requirements of 8.

Opening an enclosure (doors, lids, covers, or the like) shall only be possible when the enclosure has one of the following structures:

6.1.1.1.1 When Use of Key or Tool is Necessary This structure is only allowed for access by the electrical operator⁽³⁾. Live parts inside the enclosure shall be protected by barriers⁽⁴⁾ so as to prevent unintentional contact with them when the doors are open.

Notes ⁽³⁾ When other than electrical operator needs to have access, (for example replacement of fuses) either structure specified in 6.1.1.1.2 or 6.1.1.1.3 shall be employed.

⁽⁴⁾ The barrier to prevent electric shock is the one to prevent unintentional contact, and it may be ineffective for intentional contact.

6.1.1.1.2 When All Power Supplies Inside Enclosure are Disconnected before Enclosure can be Opened or due to Opening of Enclosure The door(s) shall be interlocked with a disconnecter (for example the supply disconnecting device) so that the door(s) can only be opened, when the disconnecter is open and so that the disconnecter can only be closed when all doors are closed. However, the structure may allow release of this interlock by the electrical operator, provided that on closing the door(s) the interlock is automatically restored.

6.1.1.1.3 When Barrier, to Prevent Contact with Live Part is Provided Inside Enclosure When barriers are provided to prevent contact with live parts, such construction is allowed that the doors can be opened without use of a key or tool or without disconnection of live parts.

The barrier shall be so constructed that the removal of it requires a tool or that the removal disconnects the power supply automatically.

6.1.1.2 Protection by Insulation of Live Parts Live parts shall be completely covered with insulation which can only be removed by destruction. Such insulation shall be capable of durably withstanding the mechanical, electrical and thermal stresses to which it may be subjected in service. Coating of paint or the similar treatment alone is considered to be insufficient for protection against electric shock.

6.1.2 Protection Against Electric Shock in Case of Leak This protection is intended to prevent danger to persons in the event of an insulation failure between live parts and exposed conductive parts. For the electrical equipment, one of the measures specified in 6.1.2.1 to 6.1.2.3 shall be employed.

6.1.2.1 Protection by Automatic Disconnection of Supply The automatic disconnection of supply is intended to prevent a touch voltage at the time of occurrence of a fault could cause danger to persons and shall consist of the following measures:

(a) Connection of exposed conductive parts to the protective circuit (see 6.1.2.1.1 to 6.1.2.1.8)

(b) Automatic disconnection of power supply

The user shall employ a residual current operated circuit-breaker for each circuit which supply electricity exceeding 60 V.

6.1.2.1.1 Protective Circuit in General The protective circuit consists of the protective earthing conductors, and/or of the conductive structural parts of enclosures and/or the machine tool. All the exposed conductive parts of the electrical equipment and the machine tool shall be connected with the terminal for protective earthing in accordance with the provision of 6.1.2.1.6.

6.1.2.1.2 Connection of Protective Circuit The protective circuit shall be connected surely by means of the protective conductors or by direct structural interconnection as shown below.

- (1) The means for assembling the various metal parts may be considered as sufficient for ensuring continuity of the protective circuit, provided that the precautions taken achieve permanent good conductivity.

The connection means of protective conductors shall not have any additional function of fastening.

In the case of enclosures and conductors of aluminium or aluminium alloys, particular consideration shall be given to the danger of electrolytic corrosion.

- (2) When a part is removed for routine maintenance or any other reason, the protective circuit for the remaining parts shall not be interrupted.

- (3) Flexible metal conduits shall not be used as protective conductors unless specially designed and tested for that purpose. Flexible metal conduits and metal sheathed cables shall be connected with the protective circuit.

- (4) When removable or withdrawable parts of the electrical equipment are equipped with metal supporting surfaces, these surfaces are considered sufficient for ensuring continuity of the protective circuit, provided that the pressure exerted on them is sufficiently high.

Precautions shall be taken to achieve permanent good conductivity of the supporting surfaces.

- (5) If the electrical equipment can be withdrawn for setting or maintenance while current is passed, its exposed conductive parts shall be connected to the protective circuit by a protective conductor.

- (6) If circuits not in accordance with 6.1.2.3 are connected to devices attached to doors, covers, plates, etc., it is recommended that these parts are fitted with a protective conductor whose sectional area depends on the maximum sectional area of wire used for the apparatus attached.

The sliding contact, hinges protected against corrosion, or the like especially designed for this connection shall be considered satisfactory for the continuity of conductivity.

If no electrical equipment is attached to doors, covers, plates, etc. or if only circuits in accordance with 6.1.2.3 are connected, the usual metal hinges and fittings are allowed.

6.1.2.1.3 Exclusion of Switching or Interrupting Devices from Protective Circuit The protective circuit shall not include switching or interrupting device (fuse, switch, etc.). However, current detector is an exception.

When the protective circuit is opened for tests or measurements the circuit shall be so constructed that the opening and closing of such testing parts can only be done by the electrical operator by using a tool.

6.1.2.1.4 Switching of Protective Circuit by Plugs Where the continuity of the protective circuit is interrupted by means of connectors or plug-and-socket devices, the protective circuit shall be interrupted only after the other circuits have been interrupted and the continuity of the protective circuit shall be re-established before any other circuit is reconnected. However, this requirement does not apply to extra-low voltage circuits and ultra-low voltage circuits. This sub-clause is applicable to removable or withdrawable plug-in units.

Remark: Metallic housings of connectors and plug-and-socket devices shall be connected to the protective circuit, except the case of 6.1.2.3 or 6.1.3.

6.1.2.1.5 Cross-section of Protective Circuit The protective circuit shall be so designed that it is capable of withstanding the highest thermal and mechanical stresses that may be caused by earth-fault current which could flow the protective circuit.

The sectional area of protective circuit shall be as given in Table 1.

If a conductor material other than copper is used, its electrical resistance per unit of length shall not exceed the allowable value of copper conductor. It is permissible to use structural parts as the protective circuit if the sectional area of these parts is at least electrically equivalent to the minimum sectional area specified in Table 1.

Table 1. Guide for Selection of Sectional Area of Copper Protective Conductor

Rated current of fuses or over-load protective devices protecting the associated circuit A	Sectional area of protective copper conductor mm ²
30	2 min.
50	3.5 min.
100	5.5 min.
150	8 min.
225	14 min.
400	22 min.
600	38 min.
800	50 min.
1000	60 min.
1200	80 min.
1600	100 min.
2000	125 min.
2500	150 min.
3200	200 min.
4000	250 min.

6.1.2.1.6 Terminal for External Protective Conductor The protective earthing conductor shall be connected to the terminal for the connection of the external protective conductor specified in 5.3 (3). The terminal shall be of a size as to enable the connection of external protective conductor with a sectional area given in Table 2.

The terminal for external protective conductor shall be identified by one of the following methods:

- (1) Symbol: symbol of protective earthing terminal specified in Appendix 2
- (2) Letters: PE
- (3) Color code: green/yellow

Table 2. Sectional Area of External Protective Conductor for Determination of Terminal Size

Sectional area of phase conductor connected to the equipment	Sectional area of external protective conductor for which the terminal shall be determined
Less than 22 mm ²	Equal to that of the phase conductor
Not less than 22 mm ²	At least 50 % that of the phase conductor

6.1.2.1.7 Manual Actuators Manual actuators of electrical devices (e.g. knobs, handles and wheels) shall be either:

- (1) Made of insulating material or insulated from other conductive parts by means of supplementary insulation or reinforced insulation. This insulation shall at least be rated for the maximum voltage used in that part of the electrical equipment, where the actuator is mounted, or
- (2) electrically connected, in a secure and permanent manner, to the protective circuit.

It is preferred that parts of manual actuators which are normally grasped by the hand during operation comply with (1). Metal parts coated with paint, varnish, etc. can not be considered to comply with (1).

6.1.2.1.8 Parts which Need not be Connected to Protective Circuit
It is not necessary to connect certain exposed conductive parts to the protective circuit if they are so mounted that they do not constitute a danger because one of the following reasons:

- (1) They cannot be touched or grasped with the hand.
- (2) They are small in size (not exceeding 50 x 50 mm).
- (3) They are so located that contact with live parts or an insulation failure is impossible.

This provision applies to small parts such as screws, rivets and nameplates, on one hand and on the other hand to parts inside an enclosure, irrespective of their size, such as electromagnets of contactors or relays, iron cores of transformers and mechanical parts of devices.

6.1.2.2 Protection by Use of Class II Electrical Equipment or by Equivalent Insulation This protection is intended to prevent the appearance of dangerous voltage on the accessible parts though a fault in the basic insulation. One of the following measures shall be employed:

- (1) To use electrical devices or apparatus having double or reinforced insulation specified in JIS C 0702.
- (2) To use factory-built equipment having total insulation.
- (3) To apply supplementary or reinforced insulation to the electrical devices having the basic insulation only, in the process of installation, to achieve the same safety as the case of (1) or (2).

Remark: In order to fulfil the safety measures envisaged by 7.2.2 and 7.2.3, it is recommended to connect the conductive (but not live) parts enclosed in insulating enclosures to the protective circuit.

6.1.2.3 Protection by Use of "Functional Extra-low Voltage (FELV)" This protection is intended to prevent the appearance of dangerous voltage on exposed conductive parts on the occurrence of fault in the insulation of the circuit.

The highest voltage in this circuit shall not exceed 50 V (r.m.s. value) a.c. or 120 V d.c. (including maximum ripple of 10 (%)). In addition one of the following measures shall be employed:

- (1) One side of the circuit or one side of the power supply to the circuit shall be connected to the protective circuit associated with the higher voltages used on the machine tool and to the related exposed conductive parts.
- (2) The source of power supply and all live parts and conductors of such circuits shall be separated or isolated from circuits with higher voltages by an insulation which is applicable to the maximum voltage used in the same part of the electrical equipment or on the same part of the machine (see 11.1.4).

Metallic covering such as screens and shielding shall be connected to the protective circuit of the higher voltages.

Plugs and socket-outlets used in the functional extra-low voltage circuit shall comply with the following:

- (a) Plugs of FELV circuit shall not be able to enter socket-outlets of other circuits.
- (b) Socket-outlets of FELV circuit shall not be able to receive plugs of other circuits.

Although the circuits specified in 6.1.3 fulfil the requirements for functional extra-low voltage circuit, the functional extra-low voltage circuits and the machine extra-low voltage circuits shall not be connected by means of plugs and socket-outlets.

6.1.3 Protection against Electric Shock both in Normal Service and in Case of Fault, by "Machine Extra-low Voltage (MELV)" This protection is intended to protect persons against dangers of direct contact with live parts as well as against dangers of insulation failure between live parts and exposed conductive parts. The circuit which satisfies all the following requirements may be exempted from protection against direct contact with live parts:

- (1) The highest voltage in this circuit shall not exceed 25 V (r.m.s. value) a.c. or 60 V d.c. (including a maximum ripple of 10 %).
- (2) The maximum current which would flow in a connecting link between such live parts not protected against direct contact and exposed conductive parts shall not exceed 1 A if a.c. or 0.2 A if d.c.
- (3) Such live parts which are not protected against direct contact shall be fastened so that they can not move freely.
Such parts shall have a shape that cannot be grasped by the hand.
- (4) The source of power supply and all live parts and conductors of such circuits shall be separated or isolated from circuits with higher voltages as specified in 6.1.2.3 and 11.1.4.
- (5) One side of the circuit or one side of the power supply to the circuit shall be connected to the protective circuit associated with the higher voltages used on the machine tool and to the related exposed conductive parts.
- (6) Exposed conductive parts associated with such circuits shall be either separated or isolated from higher voltage circuits as specified in 6.1.2.3 (2) or connected to the protective circuit of the higher voltages.
- (7) Plugs and socket-outlets used in MELV circuit shall satisfy the following requirements:
 - (a) Plugs of MELV circuit shall not be able to enter socket-outlets of other circuit.
 - (b) Socket-outlets of MELV circuit shall not be able to receive plugs of other circuits.
- (8) Where such circuits are used as control or signalling circuits, they shall also fulfil the relevant requirements of 7.

6.1.4 Residual Voltages If the equipment includes elements which may retain dangerous charges after it has been switched off [e.g. capacitors with a stored energy of exceeding 0.1 J (Joule)], it is recommended that the voltage is brought down to below 120 V (peak value) within 5 s with discharge resistors.

If this is not practicable, a warning label shall be attached to the door or cover.

Where the dangerous voltage extends beyond the enclosure, it is mandatory to bring down the voltage to below 120 V (peak value) within 5 s.

Remark:

$$J = \frac{1}{2} CV^2$$

J : energy (J)

C : capacitance (μF)

V : voltage (kV)

Example:

$$C = 4 \mu\text{F}, V = 500 \text{ V}$$

$$J = \frac{1}{2} \times 4 \times 0.5^2 = 0.5 \text{ (J)}$$

6.2 Short-circuit Protection

6.2.1 General Protection (Installation of Overcurrent Breaker)

Unless otherwise specified by the user, the manufacturer of the electrical equipment is not responsible for providing short-circuit protection at the point of entry of the main supply cables to the electrical equipment. Usually this protection is provided at the origin of the main supply cables.

The manufacturer of the electrical equipment shall state on the installation drawing the data necessary for choosing the type, the characteristics and the rated or setting current of this short-circuit protective device (see 4.2.4.1 and 6.2.3).

The short-circuit protective device shall not operate within the maximum starting time of the motors same as the overload protective device.

If the short-circuit protective device is provided with means for instantaneous interruption, its current setting shall be at least 110 % of the sum of the peak currents of all motors and devices liable to be started or operated simultaneously.

6.2.2 Protection of Circuits and Branches All conductors shall be protected against short circuits by protective devices suitably chosen in accordance with 6.2.3. Devices for detection and for disconnection of short-circuit current shall be inserted in all live conductors. However, where a neutral is used [see 5.3 (2)], which is directly connected to the earth and if the sectional area of the neutral conductor is at least equal to that of the associated phase conductors, no short-circuit current detection nor disconnection is necessary in the neutral conductor (N).

Protective earthing conductors shall not contain devices for current detection nor for disconnection (see 6.1.2.1.3).

One protective device may protect several branched circuits against short-circuit.

6.2.2.1 Protection by Fuses or Molded-case Circuit-breakers Fuses which are readily obtained by the user shall be selected.

The interrupting capacity shall be at least equal to the prospective short-circuit current at the place of installation.

A lower interrupting capacity is permitted if another protective device having the necessary breaking capacity is installed on the supply side. In this case the instantaneous tripping current setting of the protective device on the supply side shall be set to a value not exceeding 80 % of the current which can safely be interrupted by the protective device on the load side.

6.2.2.2 Protection by Relays Protection by instantaneous overcurrent relays in branched circuits acting on a protective device having a sufficient interrupting capacity is admissible as a short-circuit protective device. The disconnecting device may either interrupt one or several circuits or branched circuits.

This disconnecting device may be the general protective device or the emergency stopping device (see 6.6).

6.2.3 Rating and Setting of Short-circuit Protective Devices The rated current of fuses or the setting current of other short-circuit protective devices shall be selected as low as possible. However, such rating or setting shall be capable of withstanding transient currents such as starting currents of motor and rush currents of transformer.

The rated or the setting current of a short-circuit protective device is determined by the smallest sectional area of the conductors to be protected by that device. The short-circuit protective device shall be so selected that it operates before the conductor reaches the dangerous temperature due to the short-circuit current.

- Remarks 1. When p.v.c. insulated wires are used, Attached Table 2 shall be followed.
2. The sectional areas of insulated wires shall be as specified in 10.3.
 3. The wiring of electronic circuits with steady currents not exceeding 2 A, which is located within an enclosure of electronic equipment, as well as the wiring of low power level circuits on circuit boards or within components need not comply with Attached Tables 1 and 2.
 4. The short-circuit protective devices shall be chosen not only to protect the conductors, but also to take into account the needs of co-ordination with the other electrical devices. The short-circuit protection of electronic devices shall be as specified by the manufacturer.

6.2.4 Short-circuit Protection of Conductors in Front of Protective Device
If the conductors (with a smaller sectional area) connecting a supply circuit (with a larger sectional area) with the short-circuit protective devices of branched circuits are complying with the requirements given below, any short-circuit protection other than that specified in 6.2.2 is not necessary.

- (1) The sectional area of smaller conductor is at least equal to that required for the conductors after these protective devices in their run.

- (2) The length of the thinner conductor is not more than 3 m.
- (3) The thinner conductors are protected against external influences by an enclosure or a duct.
- (4) The thinner conductors are not placed close to combustible material.

6.3 Overload Protections

6.3.1 Protection of Motors Protection of motors shall be as follows.

- (1) Protection of motors against over loading shall be provided for each motor. However, when the rated output is not more than 0.2 kW or when one of the conditions given below is complied with such cases are exceptions.
 - (a) When a motor is installed at a location where the motor is always supervised by the operator during running.
 - (b) When burning of motor is not anticipated due to construction of the motor or to the nature of the load.
 - (c) When the motor is a single-phase one and the rated current of the overcurrent breaker installed in the power supply side lines is not exceeding 15 A (20 A for molded-case circuit-breaker).
- (2) Elements for detection of overload (except in case of built-in thermal detector) and contacts for switching shall be inserted in all live conductors except the neutral conductor (N). However, the number of overload detection elements may be reduced subject to agreement between the parties concerned with the acceptance.
- (3) The switching contacts for one and the same motor shall open and close simultaneously.
- (4) For motors which are frequently started or braked, it is recommended to use such protection as inverse time relays of non-thermal type, overload relays with saturable reactor or a thermal detected built-in the motor.
- (5) The protection by built-in thermal detector is recommended, for motors where the cooling is insufficient due to surrounding conditions during service.

6.3.2 Automatic Reset Protective Device For overload protective device of automatic reset type, appropriate means shall be provided to prevent automatic re-starting to avoid dangers due to the re-start.

6.3.3 Protection of Socket-outlets Overload detecting elements and contacts for switching shall be inserted in the live conductors, except the neutral, of each circuit to be connected to a general purpose socket outlet.

6.4 No-voltage Protection Where automatic restarting of a machine tool after interruption and restoration of the power supply may cause risk to the operator or damage to the machine tool or the work, an appropriate no-voltage protection shall be employed.

6.5 Undervoltage Protection Where voltage drop might cause malfunctioning of the electrical equipment with consequential danger to the operator or damage to the machine tool or the work, an appropriate undervoltage protection shall be employed.

6.6 Emergency Stopping and Supply Disconnecting Devices The electrical equipment of a machine tool shall have the following two functions:

- (1) Function to stop the machine quickly in case of emergency. Reverse motion to disengage the dangerous state is allowed.
- (2) Function to disconnect the electrical equipment from the power supply network.

If for both functions the same circuits have to be interrupted, on device fulfilling all the requirements of both 6.6.1 and 6.6.2 may serve for both functions.

6.6.1 Emergency Stopping Device The emergency stopping device is a device which can quickly stop the machine tool to avoid injury to the operator or damage to the machine tool, and it shall employ one of the following methods:

- (1) Installation of an emergency stopping switch which can control the power supply circuit to the machine tool electrically or manually.
- (2) Such arrangement of the control circuits that the magnetic contactors or the like in the circuit in which hazards are anticipated are released simultaneously by a single command.

Where several magnetic contactors are used, such as reversing and star/delta contactors, for the same motor, all the operating coils of these contactors shall be de-magnetized.

If reverse current braking (plugging) is used for the emergency stop or if motors are reversed for disengagement from dangerous state, the involved power supply circuits shall be interrupted after such safety measures have been completed.

The signal commanding the interruption shall be transmitted to the switching device either by a direct mechanical link or by interrupting a normally energized control circuit.

6.6.1.1 Electrical Performance of Emergency Stopping Device The emergency stopping device shall have the following electrical performances:

- (1) The device according to 6.6.1 (1) shall be capable of interrupting the maximum overload current (the total of the locked-rotor current of a motor of the largest capacity plus the sum of the normal running current of all the other equipment) of the machine tool.

- (2) The device according to 6.6.1 (2) shall be capable of interrupting the control circuit current sufficiently.

If the interrupting means of the emergency stopping device (e.g. molded-case circuit-breakers, contactors) have a sufficient breaking capacity, they may serve as protection against overload and/or short circuit.

6.6.1.2 Function of Emergency Stopping Device The operation of the emergency stopping device shall not endanger the operator or the machine tool. The power supply to such auxiliary equipment which must continue to function even under emergency conditions as magnetic chucks or braking devices shall not be interrupted.

Where necessary for the safety of the operator, withdrawal motions shall be started by the actuation of the emergency stopping device. The re-setting of an emergency stopping device shall not re-start the machine tool.

6.6.1.3 Construction and Arrangement of Emergency Stopping Device The actuator(s) for the emergency stop shall be as follows:

- (1) Handle type ones
- (2) Mushroom type push button
- (3) (a) cord(s) extending along the working area (which initiates the emergency stop when pulled and when it is disrupted)
- (4) (a) stop rail(s) or pedal(s) (without mechanical guard)
- (5) Other device suitable for the purpose.

Actuators for emergency stop shall be located in a manner to be readily visible and quickly reached by the operator from his working and operating positions. If there are two or more working or operating stations or other critical places, from each of them an actuator shall be easily reached or preferably each one of them be provided with an actuator.

All these actuators shall be colored red.

The surfaces on which actuators of handle or push button type are mounted shall be colored yellow.

If there are several actuators, it shall only be possible to restart the machine tool after all actuators have been reset.

6.6.2 Power Supply Disconnecting Device The power supply disconnecting device shall be capable of disconnecting manually the electric equipment of machine tool from the power supply. Large machine tools with several working stations, each with its own separate electrical equipment, may be provided with separate power supply disconnecting device for each station.

If there are two or more power supplies, separate power supply disconnecting device shall be provided for each power supply. Where possible danger or damage may be caused by operating one power supply disconnecting device only, an appropriate interlocking function shall be given to the control circuit or the power supply disconnecting device.

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

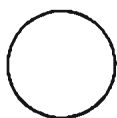
- (a) A switch-disconnector having sufficient make-break capability
- (b) A disconnector having a special auxiliary contact which causes the contactors to break the load before the opening of main contacts of the disconnector
- (c) Molded-case circuit-breaker

The power supply disconnecting device shall comply with the following requirements:

- (1) If a power supply disconnecting device so placed as to be readily accessible to the operator, the breaking capacity of the apparatus specified in (a) or (c) above shall be capable of interrupting the maximum overload current of the machine tool same as the emergency stopping device.
- (2) The power supply disconnecting device shall be as follows:
 - (a) The device shall have stable OFF position and ON position, and each of them shall be indicated by the symbols of Fig. 2.

Fig. 2

OFF indication



ON indication



- (b) The gaps can be verified on all the contacts at OFF position or the position indicator cannot indicate OFF until adequate breaking distance is achieved between the contacts.
- (c) The disconnector shall be equipped with an external operating handle. If the disconnector does not serve also as an emergency stopping device, black or gray is recommended as the color of its handle. Red shall not be used.
- (d) The disconnector shall be equipped with a device permitting it to be locked in the open position.
- (e) The disconnector shall have a function for opening all the load circuits except the neutral conductors.
- (3) When a molded-case circuit-breaker is used as a disconnector in the power circuit, it shall fulfil the following requirements:
 - (a) It shall have a handle for manual operation (this handle needs not be operated from the outside, if there are other means on the outside to open the breaker).

- (b) When locked in open position, manual as well as remote closing shall be prevented.
- (4) The handle of the disconnecter shall be easily accessible and located between 600 mm and 1900 mm above the servicing level.
- (5) The following circuits may be connected to the primary side of the power supply disconnecting device.
 - (a) Power supply circuits for lightening needed during maintenance of repair.
 - (b) Socket-outlet circuits for the exclusive connection of repair and maintenance tools like hand drills or the measuring apparatus.
 - (c) Undervoltage tripping circuits
 - (d) Control circuits specified in (7)

If voltages remain in certain circuits connected to the primary side of the disconnecter, such fact shall be stated in the maintenance instruction and indicated on the warning label placed in proximity to the power supply disconnecting device. It is recommended that such circuits are provided with their own disconnecting device.
- (6) All the exposed parts which are still live after opening the power supply disconnecting device, shall be separately covered, in order to prevent electric shock. Such covers shall be marked with the warning sign specified in 4.1.1. However, for circuits which fulfil the requirements of 6.1.2.3 and 6.1.3, this item does not apply.
- (7) It is recommended to use orange for the color of conductors in circuits which are supplied from outside, and which remain live when the power supply disconnecting device is open, to distinguish them from other circuits. If there is an appropriate warning label, item (6) does not apply to these circuits.

6.7 Protection against Maloperation The following measures shall be taken to avoid dangers due to maloperation of the electrical equipment:

- (1) Mechanical safety precaution on the machine
- (2) Proper interlocking of electrical circuits controlling mechanical movement
- (3) Additional circuits providing safety function
- (4) Double checking circuit

It is recommended to employ one or more of the above (1) to (4) and other measures simultaneously.