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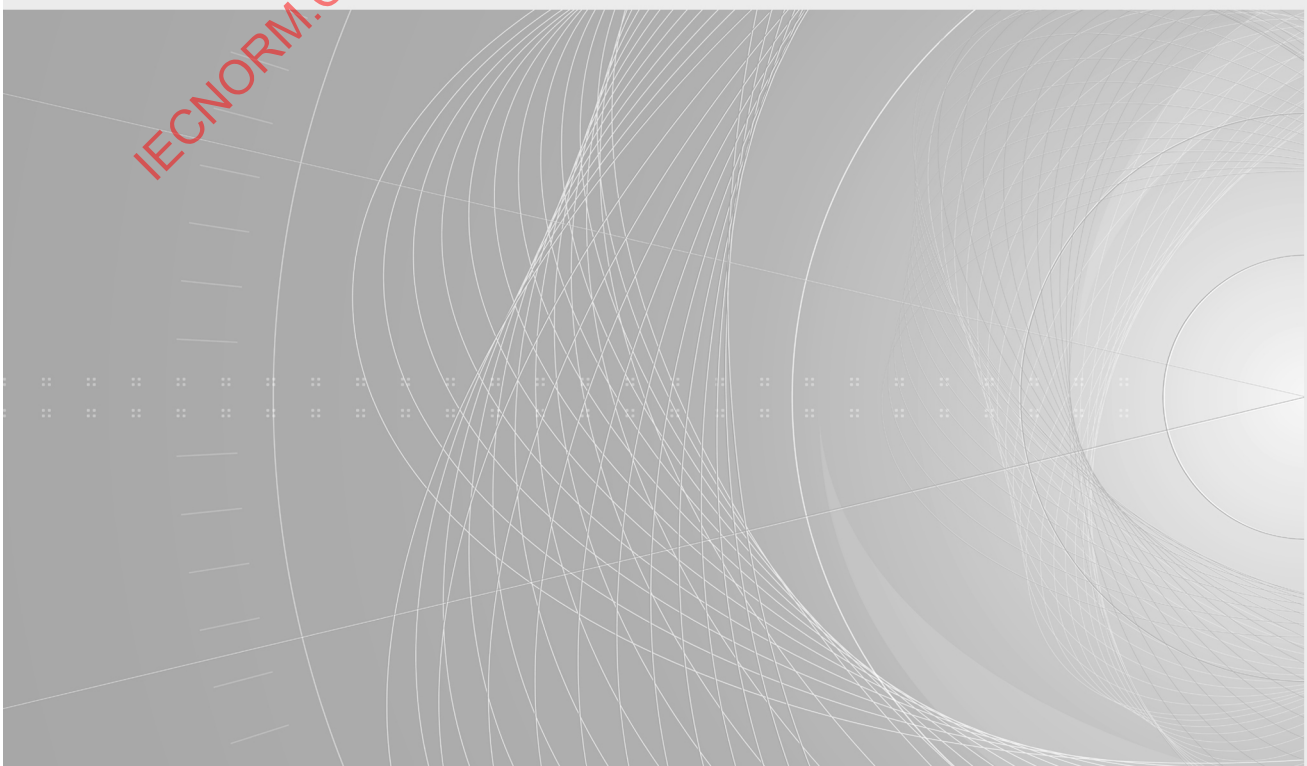
TECHNICAL SPECIFICATION

Safety of machinery – Electrical equipment of machines –
Part 34: Requirements for machine tools



IEC TS 60204-34:2016-08(en)

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Safety of machinery – Electrical equipment of machines – Part 34: Requirements for machine tools

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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SAFETY OF MACHINERY – ELECTRICAL EQUIPMENT OF MACHINES –

Part 34 : Requirements for machine tools

FOREWORD

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- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 60204-34, which is a technical specification, has been prepared by IEC technical committee 44: Safety of machinery – Electrotechnical aspects.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
44/735/DTS	44/748/RVC

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

This part of IEC 60204 is intended to be used in conjunction with IEC 60204-1:—[1].

This part supplements or modifies the corresponding clauses in IEC 60204-1.

The numbering system is based on IEC 60204-31:2013. Where a particular clause or subclause of Part 1 is not mentioned in this Part 34, that clause or subclause applies as far as is reasonable. Where this part states "addition", "modification" or "replacement", the relevant text, notes, figures, and tables in Part 1 are to be adapted accordingly.

Annexes which are additional to those in part 1 are lettered AA, BB, CC, DD, EE and FF.

A list of all parts in the IEC 60204 series, published under the general title *Safety of machinery – Electrical equipment of machines*, can be found on the IEC website.

A bilingual version of this publication may be issued at a later date.

[1] Stage at the time of publication: IEC/FDIS 60204-1:2016.

SAFETY OF MACHINERY – ELECTRICAL EQUIPMENT OF MACHINES –

Part 34 : Requirements for machine tools

1 Scope

This clause of IEC 60204-1 is applicable except as follows:

Replacement:

This part of IEC 60204 applies to electrical, electronic and programmable electronic equipment and systems of machine tools not portable by hand while working, including a group of machines working together in a co-ordinated manner.

In this part of IEC 60204, machine tools means all machines for the working of metal, wood, plastics and stone, operating by forming or removal of material. The following list includes examples of machine tools but not limited to:

– Turning machines (i.e. manually controlled turning machines without numerical control, manually controlled turning machines with limited numerically controlled capability, numerically controlled turning machines and turning centres, single– or multi-spindle automatic turning machines);
– Milling machines(including boring machines);
– Machining centres;
– Planing machines;
– Drilling machines;
– Grinding machines;
– Laser processing machines;
– Electro Discharge Machines(EDM) (except their power circuit for discharge);
– Sawing machines for cold metal;
– Guillotine shears;
– Hydraulic press brakes;
– Mechanical (or hydraulic, pneumatic) presses.

Power circuits where electrical energy is directly used as a working tool are excluded from this part of IEC 60204.

In addition to this document, the applicable C-standard for the machines listed in the examples can be referred for more information.

2 Normative references

This clause of IEC 60204-1 is applicable except as follows:

Additional references:

IEC 60204-1:—, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*

IEC 60825-1, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC 60825-4, *Safety of laser products – Part 4: Laser guards*

ISO 14119, *Safety of machinery – Interlocking devices associated with guards – Principles for design and selection*

3 Terms and definitions

This clause of IEC 60204-1 is applicable except as follows:

Additional definitions:

3.101
machine tool
MT
machine, not portable as a whole during its operation, driven by an external electrical energy source and intended to work material in the solid state, with material removal (cutting processes as turning, milling, grinding, drilling, machining…) or without material removal (forming processes such as bending, forging, etc.)

Note 1 to entry: The machine tool is normally equipped with a power supply, an electrical and electronic assembly for power and control and one or more power drive systems for the movement of elements or parts.

[SOURCE: EN 50370-1:2005, 3.1, modified — “typically metal products” has been changed to “work material”. The last sentence has been changed to NOTE 1 to entry.]

3.102
numerical control
NC
automatic control of process performed by a device that makes use of numerical data introduced while the operation is in progress

[SOURCE: ISO 2806:1994, 2.1.1]

3.103
computerized numerical control
CNC
realization of NC(3.102) using a computer to control the machine functions

[SOURCE: ISO 2806:1994, 2.1.2]

3.104
safety integrity level
SIL
discrete level (one out of a possible three), corresponding to a range of safety integrity values, where safety integrity level 3 has the highest level of safety integrity and safety integrity level 1 has the lowest

[SOURCE: IEC 61508-4:2010, 3.5.6, modified — The words "one out of a possible four" have been replaced by " one out of a possible three" and the words "safety integrity level 4" have been replaced by "safety integrity level 3".]

3.105
type test
test made on one or more equipment representative of the production in order to confirm that the design fulfils certain specifications

[SOURCE: IEC 60050-151:2001, 151-16-16, modified — The word "conformity" has been removed before "test made…", the word "items" has been replaced by "equipment" and the text from "in order to" has been added.]

3.106
performance level
PL
discrete level used to specify the ability of safety-related parts of control systems to perform a safety function under foreseeable conditions

[SOURCE: ISO 13849-1:2015, 3.1.23]

3.1000 Abbreviated terms

This subclause of IEC 60204-1 is applicable except as follows:

The abbreviations listed in Table 1 below are used in this Technical Specification.

Table 1 – List of terms and abbreviations

AC	Alternating Current
CNC	Computerized Numerical Control
CPU	Central Processing Unit
DC	Direct Current
EDM	Electro Discharge Machines
EMC	Electromagnetic Compatibility
ESPE	Electro-Sensitive Protective Equipment
I/O	Input / Output
IP	Ingress Protection
LED	Light-Emitting Diode
MT	Machine Tool
NC	Numerical Control
PELV	Protective Extra-Low Voltage
PL	Performance Level
PWB	Printed Wiring Board
RAM	Random Access Memory
RCD	Residual Current Device
SELV	safety Extra-Low Voltage
SIL	Safety Integrity Level

4 General requirements

This clause of IEC 60204-1 is applicable except as follows:

4.4.2 Electromagnetic compatibility (EMC)

Addition:

NOTE 2 Additional guidance can be found in Annex AA.

4.4.3 Ambient air temperature

Addition:

Manufacturer of machine tools could specify a lower minimum and/or a higher maximum ambient air temperatures according to application of the equipment of machine tools.

4.4.5 Altitude

Addition:

NOTE More information about the insulation coordination at the altitudes more than 1 000 m can be found in IEC 60664-1.

4.4.7 Ionizing and non-ionizing radiation

Addition:

Laser processing machines can generate laser radiation. Laser class according to IEC 60825-1 shall be stated and laser hazard label which correspond to the laser class need to be affixed, and laser hazards shall be minimised according to IEC 60825-1 and IEC 60825-4. IEC 60825-4 specifies requirements for laser guards.

NOTE Further requirements on industrial laser equipment can be found in IEC 60519-12. Further information can be found in ISO 11553-1.

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

This clause of IEC 60204-1 is applicable except as follows:

5.1 Incoming supply conductor terminations

Addition:

Add after the first sentence of the first paragraph:

When a machine tool needs to use several electrical cabinets, it is recommended that the main power supply is connected to the main power switch of one single electrical cabinet. If other cabinets need a power supply, it is recommended that they connect to the main power switch of this one single electrical cabinet.

For machinery, where two or more incoming supplies are provided, see Clause 5 of IEC 60204-1:—.

6 Protection against electric shock

This clause of IEC 60204-1 is applicable

7 Protection of equipment

This clause of IEC 60204-1 is applicable

8 Equipotential bonding

This clause of IEC 60204-1 is applicable except as follows:

8.2.3 Continuity of the protective bonding circuit

Addition:

It shall be assured that the bed and the electrical cabinet of a machine tool have continuity to the protective bonding circuit.

9 Control circuits and control functions

Addition:

See Annex BB for numerical control system of machine tools.

9.1.2 Control circuit voltages

Addition:

Add after the final paragraph:

It is recommended that the control circuit voltage be one of the following but not limited to:

– 6/24/48/100/110/120/200/220/230 V (AC);
– 5/6/12/24/48/110/220 V (DC);

9.2.3.5 Operating modes

Addition:

Add after the final paragraph:

Numerical control machine tools usually have many operating modes, for example manual mode, automatic mode, setting mode, service mode, etc.

Mode selector shall ensure that only one mode is active at anytime. The parts of the control system provided for mode selector shall be assigned to a suitable PL of ISO 13849-1 or SIL of IEC 62061. Required PL or SIL should be selected by risk assessment or in accordance with relevant type-C standards, e.g. ISO 23125.

9.3 Protective interlocks

Addition:

Add a new subclause:

9.3.7 Interlocking guards with guard locking

If hazardous situations still exist after removal of power, an interlocking guard with guard locking (see also ISO 14119) shall be provided, fulfilling a suitable PL of ISO 13849-1 or SIL of IEC 62061. Required PL or SIL should be selected by risk assessment or in accordance with relevant type-C standards, e.g. ISO 23125.

9.4 Control functions in the event of failure

Addition:

Add a new subclause:

9.4.4 Levels of functional safety

Functional safety is part of the overall safety that depends on a system or equipment operating correctly in response to its inputs.

For the purposes of ISO 13849, the ability of safety-related parts to perform a safety function is expressed through the determination of the performance level (PL).

According to IEC 62061 and IEC 61508, the ability of safety-related control systems to perform a safety function is given through a SIL. Table 2 displays the relationship between the two concepts (PLs and SILs). See Annex A of ISO 13849-1:2006 for determination of required performance level (PLs); a SIL example of a methodology is given in Annex A of IEC 62061:2005, IEC 62061:2005/AMD1:2012 and IEC 62061:2005/AMD2:2015.

Detailed information to implement functional safety is given in ISO 13849-1, IEC 62061, IEC 61508, IEC 61131-6.

Table 2 – SIL and PL

Safety integrity level **SIL** (IEC 61508-1 or IEC 62061, for information) continuous mode of operation	**Probability of dangerous failures per hour (i/h)**	**Performance level** **PL**
–	$\geq 10^{-5}$ to $< 10^{-4}$	a
SIL1	$\geq 3 \times 10^{-6}$ to $< 10^{-5}$	b
SIL1	$\geq 10^{-6}$ to $< 3 \times 10^{-6}$	c
SIL2	$\geq 10^{-7}$ to $< 10^{-6}$	d
SIL3	$\geq 10^{-8}$ to $< 10^{-7}$	e

NOTE Table 2 is based on ISO 13849-1, IEC 61508-1 and IEC 62061.

10 Operator interface and machine-mounted control devices

This clause of IEC 60204-1 is applicable except as follows:

10.3.2 Colours

Modification:

Add an example in the last line, last column of Table 4, as follows:

Table 4 – Colours for indicator lights and their meanings with respect to the condition of the machine

Colour	Meaning	Explanation	Action by operator
RED	Emergency	Hazardous condition	Immediate action to deal with hazardous condition (for example switching off the machine supply, being alert to the hazardous condition and staying clear of the machine)
YELLOW	Abnormal	Abnormal condition Impending critical condition	Monitoring and/or intervention (for example by re-establishing the intended function)
BLUE	Mandatory	Indication of a condition that requires action by the operator	Mandatory action
GREEN	Normal	Normal condition	Optional
WHITE	Neutral	Other conditions; may be used whenever doubt exists about the application of RED, YELLOW, GREEN, BLUE	Monitoring (e.g. power indicating)

10.6 Start devices

Addition:

For example, the start pushbutton can be of the recessed or flush type or protected by a cover.

11 Controlgear: location, mounting, and enclosures

This clause of IEC 60204-1 is applicable except as follows:

11.2.3 Heating effects

Addition:

Where heat dissipation of the housing of the enclosure is not sufficient to keep the temperature inside under the limits of the components, means for temperature control shall be provided, for example:

– Forced circulation of the air inside the enclosure
– Forced ventilation
– Forced ventilation with air conditioning
– Local cooling (coolant circulation, peltier element, etc.)

Where the risk of condensation of water exists, heating elements should be provided.

11.3 Degrees of protection

Replacement:

Replace the third indent of NOTE 2 as follows:

– Enclosure used to endure the environment with water and/or dust invasion from all directions IP54

– Enclosure used to endure the environment with water invasion from above IP43

– Enclosure used to endure the environment without water droplets IP32

11.4 Enclosures, doors and openings

Addition:

Add after the final dashed indent of the last paragraph:

A pocket to accommodate electrical drawing and/or manuals should be attached where practicable.

12 Conductors and cables

This clause of IEC 60204-1 is applicable

13 Wiring practices

This clause of IEC 60204-1 is applicable

14 Electric motors and associated equipment

This clause of IEC 60204-1 is applicable

15 Socket-outlets and lighting

This clause of IEC 60204-1 is applicable

16 Marking, warning signs and reference designations

This clause of IEC 60204-1 is applicable

17 Technical documentation

This clause of IEC 60204-1 is applicable except as follows:

17.1 General

Addition:

Add after the first paragraph:

See Annex CC for Graphical symbols for machine tools.

See Annex DD for reference designations for electrical diagrams of machine tools.

See Annex EE for electrical diagrams for machine tools.

17.2 Information related to the electrical equipment

Addition:

Add after the first indent of 17.2 e):

- function menu and function description for auxiliary code M (CNC), if implemented in the CNC (computerized numerical control);

NOTE 1 "Function menu" is a list of typical work piece processing programs (CNC).

NOTE 2 "Auxiliary code M" is a command used in NC that initiates discrete functions of machine or control system (ISO 2806:1994 2.6.2, modified).

- table for parameters of macro function and/or set values (CNC), if necessary for using the machine.

NOTE 3 Macro function is a subroutine used in machine program for numerical control of machines. It has capability to handle a parameter.

18 Verification

Modification:

18.1 is replaced and, 18.8, 18.9 and 18.10 are new subclauses added.

18.1 General

Replacement:

The extent of verification will be given in the dedicated product standard for a particular machine. Where there is no dedicated product standard for the machine, the verifications shall always include the items a), b), c), h) and i) and may include one or more of the items d), e), f), g), j) and k):

a) verification that the electrical equipment complies with its technical documentation;

b) verification of continuity of the protective bonding circuit (see Test 1 of 18.2.2 of IEC 60204-1:—);

c) in case of fault protection by automatic disconnection of supply, conditions for protection by automatic disconnection shall be verified according to IEC 60204-1:—, 18.2;

d) insulation resistance test (see IEC 60204-1:—, 18.3);

e) voltage test (see IEC 60204-1:—, 18.4);

f) protection against residual voltage (see IEC 60204-1:—, 18.5);

g) verification that the relevant requirements of IEC 60204-1:—, 8.2.6 are met;

h) functional tests (see IEC 60204-1:—, 18.6).

i) visual inspection (see 18.8)

j) idle tests (see 18.9);

k) load tests (see 18.10).

When these tests are performed, it is recommended that they follow the sequence listed above.

When the electrical equipment is modified, the requirements stated in IEC 60204-1:—, 18.7 shall apply.

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

The results of the verification shall be documented.

Additional subclauses:

18.8 Visual inspection

Electrical equipment of machine tool shall be inspected to verify that:

– the selection and adjustment of overload protecting devices is correct;
– protection by enclosures described in IEC 60204-1:—, 6.2.2 is applied;
– emergency stop devices are easily accessible;
– each electrical component is correctly installed (e.g. fasteners, secured);
– each termination is connected securely;
– the colour of each button, signal lamp, and cursor buttons comply with the requirements of IEC 60204-1:—, 10.2, 10.3;
– switching capacity of contactor is greater than or equal to rated load current;
– cable routing, cable support and cable type are correct, and terminations/cores/cables are not subject to over tensile stress, small cable bending radius, excessive lengths or sharp edges.

18.9 Idle tests

Electrical equipment of machine tool shall be running without load to verify:

– the complete electrical equipments of machine tool are working properly on integrated machine;
– action sequence is correct;
– functions are complete and correct, and each safety protection measure is effective and reliable (guard interlocking, emergency stop, enabling device, etc.).

Idle tests should be executed for each single individual specimen of a machine tool.

18.10 Load tests

Load test shall be executed in the prototype testing or in product type testing.

Electrical equipment of machine tool shall be run continuously until stable temperature is reached at load and conditions specified by manufacturers to verify proper operation (e.g. over-temperature protection).

Verify that the temperature of all electrical equipment of machine tool does not exceed any specified temperature for the components.

Annexes

The annexes of part 1 are applicable except as follows:

Addition:

Annex AA
(informative)

EMC

AA.0 General

Annex AA gives guidance for the proper usage of EN 50370-1 and EN 50370-2, which provide information specifically for machine tools.

NOTE 1 The generic EMC standards IEC 61000-6-1 or IEC 61000-6-2 and IEC 61000-6-3 or IEC 61000-6-4 provide general EMC emission and immunity limits (see also IEC 60204-1:—, 4.4.2).

NOTE 2 Relevant product standards can specify additional EMC requirements (e.g. IEC 61800-3 for power drive systems).

Annex AA is not applicable to EDM.

If the machine tool contains no electromagnetically relevant components, no tests are required.

Annex AA is provided for general guidance. It should be noted that the actual requirements in the latest edition of the referenced standard can be different and should be complied with.

AA.1 System configuration

A basic configuration may consist of (see Figure 1 "System configuration and example of ports" of EN 50370-1:2005)

– An electrical feeding section;
– Control and protection circuits and equipment;
– One or more basic power conditioning units (example: drive modules) performing control and/or conversion of electrical energy;
– One or more actuators and their associated transducers;
– Control and sequencing systems such as NC-controllers, programmable controllers and their associated peripherals, programming and debugging tools, test equipment and human-machine interfaces (parts (e.g. HMI panel) which are not permanent parts of the CNC system should not cause malfunction of the CNC system when establishing communication (see also 9.2.3 of IEC 60204-1:—));
– Peripherals (transducer(s), operator station, emergency stop devices, etc.);
– The structure and the moving parts driven by the actuator(s).

AA.2 Test approach

NOTE The following text is derived from Clause 4 of EN 50370-1:2005.

Type testing of a finished product is the normal method for conformity assessment against the requirements of a standard, but complete testing of an entire machine tool at a conventional EMC test site is only technically possible and economically feasible for a limited number of machines. A distinction should be drawn between type-testable machines and machines which, because of the weight, dimensions, operation or unreasonable testing costs and testing delay, cannot be type-tested as a whole at a conventional EMC test site.

Furthermore, it is necessary to take single-piece production and the multitude of types into account as well as expansions and modifications.

Distinctions should be drawn between the following cases and should be taken into account:

– Type-testable machines;
– Machines which are not type-testable;
– Multitude of types;
– Modifications, additions and expansions.

Each testing procedure for conformity assessment is based on one or a combination of various tests:

– Type test at the EMC test site;
– Visual inspection of entire machine tool;
– Additional tests on entire machine tool.

AA.3 Emission

The electrical disturbances generated by the electrical equipment of machine tools should not exceed the levels specified in Table “type test requirements” in Annex A of EN 50370-1:2005. Emission measurements should be performed in accordance with CISPR 11 and CISPR 16.

NOTE The machine tool builder does not need to repeat measurements on an EMC compliant module as declared by its manufacturer.

AA.4 Immunity

AA.4.1 General

Where electronic equipment is used, it should be designed to withstand at least values specified in Table A.1 “Machine tools immunity tests – Enclosure port”, Table A.2 “Machine tools immunity tests – Ports for signal ports”, Table A.3 “Machine tools immunity tests – DC input and output power ports”, Table A.4 “Machine tools immunity tests – AC input and output power ports” and Table A.5 “Machine tools immunity tests – Functional earth port” in Annex A of EN 50370-2:2003.

AA.4.2 Performance criteria

The assessment of performance degradation used during and/or at the conclusion of the tests, should be simple, but at the same time give adequate proof that the essential functions of the machine tool are operative. The performance criteria should be used to check the performance of a machine tool or modules against external disturbances.

Since machine tools and their modules represent a very broad and inhomogeneous group of products, a precise definition of performance criteria cannot be given.

Nevertheless a functional description and a definition of performance criteria and monitoring methods, during or as a consequence of the EMC testing, should be specified by the manufacturer and included in the test report, based on the general criteria and examples of malfunctioning contained in Table 2 “Performance criteria definition” of EN 50370-2:2003, which cannot be considered exhaustive.

It is the responsibility of the manufacturer to define the representative parameters for each specific performance and the permissible degradation of performance or loss of function of the machine tool or the module(s). Table AA.7 classifies the effects of a given disturbance into three performance criteria: A, B and C, each of which defines a specified level of performance.

NOTE Alternatively, IEC 61000-6-2:2005, Clause 4, criterion A) or B) can be used.

Annex BB
(informative)

Numerical control system of machine tools

BB.1 General

The purpose of Annex BB is to explain requirements and related tests for the numerical control system of machine tools.

Annex BB applies to any numerical control systems of machine tools.

If safety of machine tools is realized by safety related part of Numerical control system, the Numerical control system should comply with the safety requirements of relevant IEC/ISO standards.

Function definition of all numerical control systems should be in accordance with ISO 2806.

Coordinate axis and motion direction should be in accordance with ISO 841.

Data format for positioning, line motion and contouring control systems should be in accordance with ISO 6983-1.

A numerical control system consists of numerical controller, power drive system, PLC, sensors, etc. A detailed component list with relevant standards (e.g. amongst others IEC 61800-5-1 for safety requirements for power drive system, IEC 60034-1 for motors, IEC 61010-2-201 or IEC 61131-2 for PLC) is given in Annex FF. Annex BB is provided for general guidance. It should be taken into consideration that the actual requirements in the latest edition of the relevant standards can be different and should be complied with.

BB.2 Function

BB.2.2 Digital I/Os

Digital I/Os should comply with the requirements of IEC 61131-2 or IEC 61010-2-201 as appropriate.

BB.2.3 Analogue I/Os

Analogue I/Os should comply with the requirements of IEC 61131-2 or IEC 61010-2-201 as appropriate.

BB.2.4 Communication interface

Type tests according to IEC 61131-2 or IEC 61010-2-201 as appropriate should be applied to communication interface and modules communication links where applicable.

BB.2.5 Fieldbus interface

Fieldbus interface should be designed and mounted in accordance with relevant parts of IEC 61158 and IEC 61784-3.

BB.2.7 Human-machine interface

Control panel should be selected, mounted, and identified or coded in accordance with IEC 61310 and IEC 60447. Control device and indicator lights colours should comply with Clause 10 of IEC 60204-1:—.

BB.2.10 Peripherals

Insertion/withdrawal of removable units should be verified.

Connectors for the peripherals should be coded to prevent improper connection, or the NC system should be designed to guarantee that no malfunction occurs if a connection is improper.

NC system should have a means to verify the version of program to be executed. And it may be done with peripherals.

If online modification of the application programme and/or the modes of operation of the NC system by a peripheral is possible (i.e. when the NC system is in active control of a machine or industrial process), then

– the peripheral should automatically give clear warnings equivalent to "during online modification, programme display may differ from application programme, control of the machine/ process may be interrupted during ... ms, etc.", as applicable.
– the peripheral should ask the operator "Do you really want to carry out this action?" or some similar words and execute the command only after a positive reply has been given by the operator.
– it should be possible to upload the new application programme to the manufacturer's supplied data media and verify, online, that the record is functionally equivalent to it; and
– means should be provided to prevent unauthorized use of these functions (hardware or software, e.g. key switch, electronic password).

BB.2.11 NC system self-tests and diagnostics

NC systems should include functions for self-tests and diagnostics. The following functions should be considered:

– a means for monitoring the application programs (e.g. watchdog timer, etc.);
– a means for memory integrity check (i.e. ECC, etc.);
– a means to check that the power supplies do not exceed the voltage and current limits allowed by the hardware design;
– a means to monitor the status of the NC system. It should be capable of operating an alarm (i.e. digital PLC output).

Remote input/output stations should be capable of operating an alarm (for example, through a digital output module) in the event of loss of power or loss of normal communication with the NC and go to a predetermined state.

BB.3 Protection against electric shock, thermal, and energy hazards

BB.3.1 General

For protection against electric shock, thermal, and energy hazards, NC systems should comply with relevant standards (see Annex FF).

BB.3.2 Fault conditions

NC systems should have capability to avoid operating modes or sequences that can cause a fault condition or component failure leading to a hazard, unless other measures to prevent the

hazard are provided by the installation. Protection against thermal hazards and electric shock is maintained in single fault conditions and normal conditions.

BB.3.3 Protection against electric shock

BB.3.3.1 General

NC systems should include basic protection (protection against direct contact) and fault protection (protection against indirect contact).

For example, IEC 61800-5-1 shows the necessary means and consideration for the protection as follows:

For basic protection:

– Insulation of live parts;
– Enclosures and barriers;
– Using DVC A (decisive voltage class A);
– protective impedance;
– limited voltages;

For fault protection:

– Insulation between live parts and accessible conductive parts;
– Protective bonding circuit;
– Protective class II;

Consideration of the following influences for insulation:

– Pollution degree (see BB.3.3.2);
– Overvoltage category (see BB.3.3.2);
– Supply earthing system;
– Insulation voltage;
– Location of insulation;
– Type of insulation;

See IEC 60664-1 for more information on insulation.

NOTE IEC 61140 provides information about classes of equipment and protective provisions.

BB.3.3.2 Pollution degree and overvoltage category

NC components without protection by enclosure (i.e. control cabinet) should have protection against pollution degree 3. NC components with protection by enclosure can have protection against pollution degree 2. See IEC 60664-1 for more information on pollution degree.

An overvoltage category according to the relevant product standard but not less than overvoltage category II should be applied.

See IEC 60364-4-44 and IEC 60664-1 for more information on overvoltage category.

BB.3.4 Protection against thermal hazards

NC systems should include protection against thermal hazards.

For example, IEC 61800-5-1 shows the requirements for PDS (power drive system) about:

– minimizing the risk of ignition due to high temperature;
– insulating materials;
– flammability of enclosure materials;
– temperature limits to internal materials and components, and external parts.

See IEC 61800-5-1 for further information.

NOTE ISO 13732-1 gives guidance for the assessment of the risks of burns when humans might touch hot surfaces with their unprotected skin.

BB.3.5 Protection against energy hazards

BB.3.5.1 Electrical energy hazards

The design of NC systems should include consideration for the following:

– Failure of any component should not release energy leading to a hazard.
– Electric energy released in short time (e. g. short circuit) may lead to a hazard (e. g. high temperature, fire, burn of body, etc.).
– Overvoltage and transients should be considered.
– Battery may cause hazard. The short circuit or overload of battery may cause fire (or explosion). Appropriate safety measure to battery should be adopted.
– Capacitors are energy storage components. The storage of energy may lead to not only energy shock, but also burn of body or fire in some cases (e. g. short circuit). Release circuit or other protective measure should be adopted.
– Electric arc is a form of energy hazard. Isolation and arc extinction measure should be adopted in case of electric arc.

BB.3.5.2 Mechanical energy hazards

Mechanical failure due to critical speed considerations or torsional problems can create a hazard to operation personnel. These considerations are applicable to all PDS, although they are increasingly significant with increased equipment size, such as with high voltage PDS. As these subjects are application-dependent, it is not possible to include specific requirements in this document.

BB.4 Test

BB.4.1 General

Testing is carried out by NC manufacturers in order to demonstrate that the NC system is fully in accordance with the requirements of the relevant standard (see Annex FF). This clause shows the test overview based on IEC 61800-5-1 only for reference.

Test related to NC systems and/or components are classified as:

- Type tests: test of one or more devices made to a certain design to show that the design meets certain specifications.
- Routine tests: test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria. This tests may include check features such as adequacy of labelling, warnings and other safety aspects.
- Sample tests: test on a number of devices taken at random from a batch.

In addition, the following inspection may be carried out with above tests.

– visual inspections;
– routine inspections.

BB.4.2 Test overview

Table BB.1 shows the test overview for reference.

Table BB.1 – Test overview

Test	Type	Routine	Sample	Requirement(s)[a]	Specification[a]
Visual inspection	X	X	X		5.2.1
Mechanical tests					5.2.2
Clearance and creepage distances	X			4.3.6.1, 4.3.6.4, 4.3.6.7	5.2.2.1
PWB short-circuit	X			4.3.6.7	5.2.2.2
Non-accessibility	X			4.3.3.3	5.2.2.3
Enclosure integrity	X			4.3.7.1	5.2.2.4
Deformation tests				4.3.6.4.3	5.2.2.5
Deflection	X			4.3.7.1	5.2.2.5.2
Impact	X			4.3.7.1	5.2.2.5.3
Electrical tests				4.3.4.1, 4.3.6.8.2	5.2.3
Impulse voltage	X		X	4.3.3.2, 4.3.4.3, 4.3.6.1, 4.3.6.8.2.1, 4.3.6.8.2.2, 4.3.6.8.3	5.2.3.1
a.c. or d.c. voltage	X	X		4.3.3.2, 4.3.4.3, 4.3.6.1, 4.3.6.8.2.1, 4.3.6.8.2.2, 4.3.6.8.4.2	5.2.3.2
Partial discharge	X		X	4.3.6.1, 4.3.6.8.2.2, 4.3.6.8.3	5.2.3.3
Protective impedance	X	X		4.3.4.3	5.2.3.4
Touch current measurement	X			4.3.5.5.2	5.2.3.5
Short-circuit test	X			4.3.9	5.2.3.6.3
Breakdown of components	X			4.2	5.2.3.6.4
Capacitor discharge	X			4.3.11	5.2.3.7
Temperature rise	X			4.3.8.8.2, 4.4.2.1	5.2.3.8
Protective bonding	X	X		4.3.5.3	5.2.3.9
Abnormal operation tests				4.2	5.2.4
Loss of phase	X			4.2	5.2.4.4
Inoperative blower	X			4.2	5.2.4.5.2
Clogged filter	X			4.2	5.2.4.5.3
Loss of coolant	X			4.4.5.2.5	5.2.4.5.4
Material tests					5.2.5
High current arcing ignition	X			4.4.2.2	5.2.5.1
Glow-wire	X			4.4.2.2	5.2.5.2
Hot wire ignition	X			4.4.2.2	5.2.5.3
Flammability	X			4.4.3	5.2.5.4
Environmental tests				4.6	5.2.6
Dry heat	X			4.6	5.2.6.3.1
Damp heat	X			4.6	5.2.6.3.2
Vibration test	X			4.6	5.2.6.4
Hydrostatic pressure	X	X		4.4.5.2.2	5.2.7

NOTE Table BB.1 is identical to Table 17 of IEC 61800-5-1:2007.

[a] Columns "Requirement(s)" and "Specification" refer to subclauses of IEC 61800-5-1:2007.

BB.5 Electromagnetic compatibility (EMC)

NC system should be designed and manufactured to ensure that:

The equipment should not generate electromagnetic disturbances above levels that are appropriate for its intended operating environment.

In addition, the equipment should have a level of immunity to electromagnetic disturbances so that it can function in its intended environment.

Tests and verifications for EMC should be performed by the manufacturer. Information on EMC for machine tool builders should be provided by the manufacturer.

Reference standards:

- See IEC 61000-6-1/IEC 61000-6-2 and IEC 61000-6-3/IEC 61000-6-4 for general EMC immunity and emission limits;
- See IEC 61800-3 for adjustable speed power drive systems (PDS), EMC requirements and test methods;
- See IEC 61131-2 (or IEC 61010-2-201 as appropriate) and IEC 61131-6 for programmable controllers, equipment requirements and tests.

See also Annex AA for numerical control system of machine tools.

BB.6 Technical documentation

See Clause 17 of IEC 60204-1:—.

Annex CC
(informative)

(Derived from IEC 60617-DB:2001)
Graphical symbols used in electrical diagrams of machine tools

Table CC.1 shows graphical symbols defined in IEC 60617-DB:2001 and the combination of these symbols which are often used on machine tools. The number shown in Table CC.1 conforms to the number of the graphical symbols shown in IEC 60617-DB:2001. The graphical symbols without the number are originally defined in this Technical Specification. Turning, mirroring, and scaling of the graphical symbols are permitted (see 5.12 of IEC 61082-1:2014). Refer to IEC 60617-DB:2001 for the graphical symbols which are not shown in Annex CC.

The purpose of Annex CC is to provide an overview of the particular information related to machine tools. It should be taken into consideration that the actual information in the latest edition of the referenced standard can be different and should be followed.

Table CC.1 – Graphical symbols for electrical equipment of machines (derived from IEC 60617-DB) *(1 of 13)*

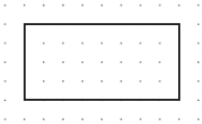
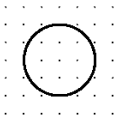
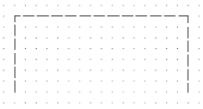
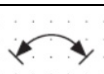
Sequence number	Symbol number	Graphical symbols	Name/explanation	Remark
1	S00060		Object	
2	S00061		Object	
3	S00064		Boundary	
4	S00065		Screen	
5	S01401		Direct current	
6	S01403		Alternating current	
7	S00077		Positive polarity	
8	S00078		Negative polarity	
9	S00081		Adjustability, General Symbol	
10	S00084		Variability, non-linear	
11	S00093		Rectilinear motion (unidirectional)	
12	S00094		Rectilinear motion (bidirectional)	
13	S00095		Circular motion (unidirectional)	
14	S00096		Circular motion (bidirectional)	
15	S00097		Circular motion (bidirectional and limited)	
16	S00115		Material, liquid	
17	S00116		Materials, gas	

Table CC.1 *(2 of 13)*

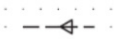
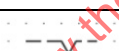
Sequence number	Symbol number	Graphical symbols	Name/explanation	Remark
18	S00120		Thermal effect	
19	S00121		Electromagnetic effect	
20	S00148		Delay Action	Form 1
21	S00149		Delay Action	Form 2
22	S00127		Radiation, electromagnetic, non-ionizing	
23	S00129		Radiation, ionizing	
24	S00144		Link	Form 1
25	S00147		Link	Form 2
26	S00150		Automatic return	
27	S00151		Detent	
28	S00154		Mechanical interlock	
29	S00167		Actuator, manual, general symbol	
30	S00168		Actuator, manual, (protected)	
31	S00169		Actuator (operated by pulling)	
32	S00170		Actuator (operated by turning)	
33	S00171		Actuator (operated by pushing)	
34	S00172		Actuator (operated by proximity effect)	
35	S00173		Actuator (operated by touching)	
36	S00174		Actuator, emergency	
37	S00176		Actuator (operated by pedal)	

Table CC.1 *(3 of 13)*

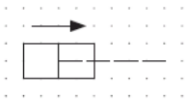
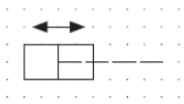
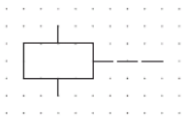
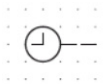
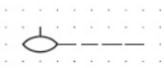
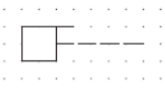
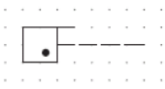
Sequence number	Symbol number	Graphical symbols	Name/explanation	Remark
38	S00177		Actuator (operated by lever)	
39	S00179		Actuator (operated by key)	
40	S00181		Actuator (operated by roller)	
41	S00182		Actuator (operated by cam)	
42	S00187		Actuator (Actuated by pneumatic or hydraulic power /single action)	
43	S00188		Actuator (Actuated by pneumatic or hydraulic power /single acting)	
44	S00189		Actuator (Actuated by electromagnetic effect)	
45	S00190		Actuator (Actuated by electrical magnetic field)	The Same meaning as the symbol 'I >'. See symbol number S00295
46	S00191		Actuator (Actuated by thermal device)	
47	S00193		Actuator (Actuated by electric clock)	
48	S00195		Actuator (Actuated by liquid level)	
49	S00196		Actuator (Actuated by a counter)	
50	S00197		Actuator (Actuated by fluid flow)	
51	S00198		Actuator (Actuated by gas flow)	
52	S00200		Earth, general symbol	

Table CC.1 *(4 of 13)*

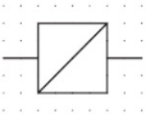
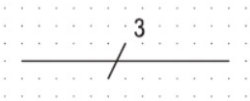
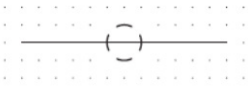
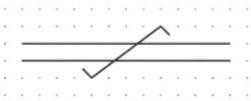
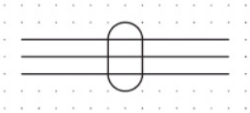
Sequence number	Symbol number	Graphical symbols	Name/explanation	Remark
53	S01408		Functional earthing, Functional grounding (US)	
54	S00202		Protective earthing	
55	S00203		Frame	
56	S00210		Permanent magnet	
57	S00213		Converter, general symbol	
58	S00214		Conversion, general symbol	
59	S00001		Connection, general symbol	
60	S00002		Groups of connections (number of connections indicated)	
61	S00003		Groups of connections (number of connections indicated)	
62	S00007		Screened conductor	
63	S00008		Twisted connection	
64	S00009		Conductors in a cable	
65	S00016		Connection point	
66	S00017		Terminal	

Table CC.1 *(5 of 13)*

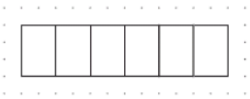
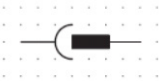
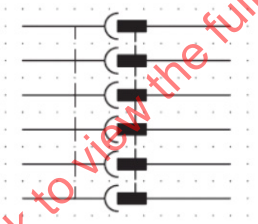
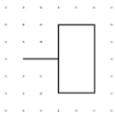
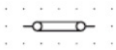
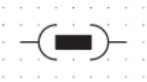
Sequence number	Symbol number	Graphical symbols	Name/explanation	Remark
67	S00018		Terminal strip	
68	S00019		T-connection	
69	S00020		T-connection	
70	S00022		Double junction of conductor	
71	S00031		Contact, female, (of a socket or plug)	
72	S00032		Contact, male, (of a socket or plug)	
73	S00033		Plug and socket	
74	S00034		Plug and socket, multipole (multi-line representation)	
75	S00036		Connector, fixed portion of an assembly	
76	S00037		Connector, movable portion of an assembly	
77	S00044		Connection link (closed), connection devices, testing points	
78	S00047		Male-male	
79	S00555		Resistor, general symbol	
80	S00557		Resistor, adjustable	

Table CC.1 *(6 of 13)*

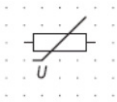
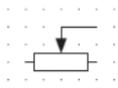
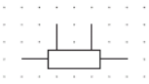
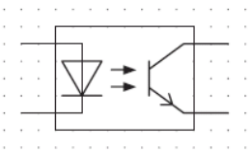
Sequence number	Symbol number	Graphical symbols	Name/explanation	Remark
81	S00558		Resistor, voltage dependent	
82	S00561		Potentiometer with movable contact	
83	S00563		Resistor with fixed tapping	
84	S00564		Resistor with separate current and voltage terminals	
85	S00567		Capacitor, general symbols	
86	S00571		Capacitor, polarized	
87	S00573		Capacitor, adjustable	
88	S00583		Inductor coil, winding, general symbol	
89	S00641		Semiconductor diode, general symbol	
90	S00646		Breakdown diode, unidirectional	
91	S00649		Bidirectional diode	
92	S00691		Optocoupler	
93	S00806		Three-phase winding, delta	

Table CC.1 *(7 of 13)*

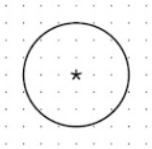
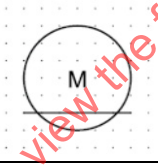
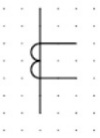
Sequence number	Symbol number	Graphical symbols	Name/explanation	Remark
94	S00808		Three-phase winding, star	
95	S00809		Three-phase winding, star, with neutral brought out	
96	S00818		Brush (on slip-ring or commutator)	
97	S00819		Motor, general symbol	C Rotary converter G Generator GS Synchronous generator M Motor MG Machine capable of use as a generator or motor MS Synchronous motor SM Servo motor
98	S00820		Linear motor, general symbol	
99	S00842		Transformer with two windings, general symbol	
100	S00847		Auto-transformer, general symbol	
101	S00851		Current transformer, general symbol	
102	S00853		Transformer with two windings and screen	

Table CC.1 *(8 of 13)*

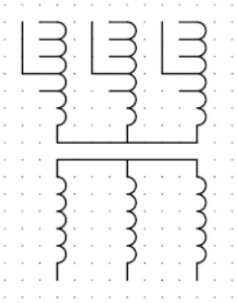
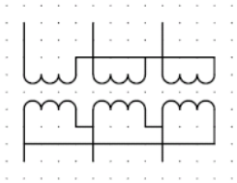
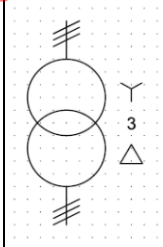
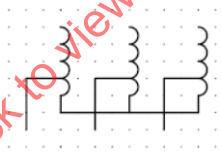
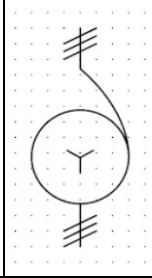
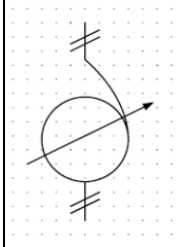
Sequence number	Symbol number	Graphical symbols	Name/explanation	Remark
103	S00861		Three phase transformer with four taps, connection: star-star	
104	S00863		Three phase bank of single-phase transformer, connection: star-delta	Form2, 
105	S00871		Auto-transformer, single phase	
106	S00873		Auto-transformer, three phase, connection: star	Form2, 
107	S00875		Auto transformer, single phase with voltage regulation	Form2, 
108	S00895		Rectifier in full wave (bridge) connection	
109	S00896		Inverter	

Table CC.1 *(9 of 13)*

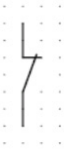
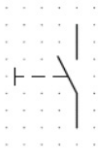
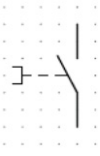
Sequence number	Symbol number	Graphical symbols	Name/explanation	Remark
110	S00898		Primary cell	
111	S00227		Make contact, general symbol; switch, general symbol	
112	S00229		Break contact	
113	S00243		Make contact, delayed closing	
114	S00244		Make contact, delayed opening	
115	S00245		Break contact, delayed opening	
116	S00246		Break contact, delayed closing	
117	S00253		Switch, manually operated, general symbol	
118	S00254		Switch, manually operated, push-button, automatic return	
119	S00255		Switch, manually operated, pulling, automatic return	

Table CC.1 *(10 of 13)*

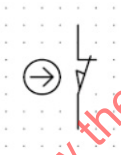
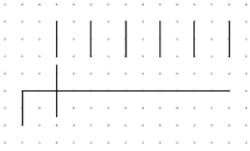
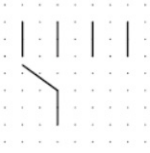
Sequence number	Symbol number	Graphical symbols	Name/explanation	Remark
120	S00256		Switch, manually operated, turning, stay-put	
121	S00258		Switch, emergency stop	
122	S00259		Position switch, make contact	
123	S00260		Position switch, break contact	
124	S00262		Position switch, break contact, positive operation	
125	S00263		Temperature sensitive switch, make contact	
126	S00264		Temperature sensitive switch, break contact	
127	S00265		Thermal switch, self-operating, break contact	
128	S00270		Multi-position switch	
129	S00271		Multi-position switch, maximum four position	

Table CC.1 *(11 of 13)*

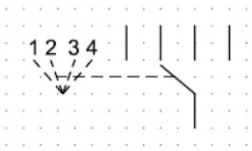
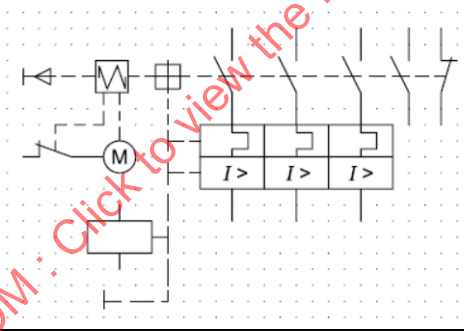
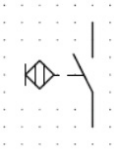
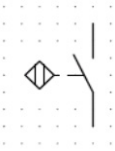
Sequence number	Symbol number	Graphical symbols	Name/explanation	Remark
130	S00272		Multi-position switch, with position diagram	
131	S00284		Contactor; main make contact of a contactor	
132	S00287		Circuit breaker	
133	S00288		Isolator	
134	S00293		Trip-free mechanism	
135	S00295		Mechanical switching device, three-pole	
136	S00358		Touch sensitive switch	
137	S00359		Proximity switch	
138	S00360		Proximity switch , magnetically controlled	

Table CC.1 *(12 of 13)*

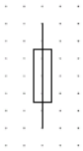
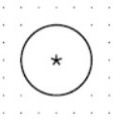
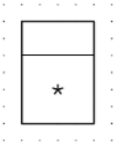
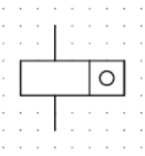
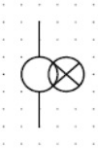
Sequence number	Symbol number	Graphical symbols	Name/explanation	Remark
139	S00362		Fuse, general symbol	
140	S00910		Indicating instrument general symbol	For the usage of *, please follow A00144
141	S00911		Recording instrument, general symbol	For the usage of *, please follow A00144
142	S00912		Integrating instrument, general symbol	For the usage of *, please follow A00144
143	S00947		Pulse counting device	
144	S00952		Thermocouple	
145	S00965		Lamp, general symbol	For the specific usage, please follow A00174
146	S00966		Signal lamp, flashing type	
147	S00973		Buzzer	
148	S00975		Signaling lamp energized by a built-in transformer	
149	S00457		Socket outlet (power), general symbol; receptacle outlet (power), general symbol	

Table CC.1 *(13 of 13)*

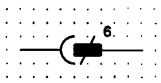
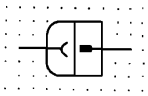
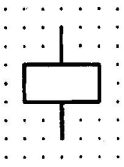
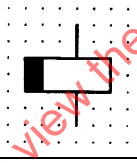
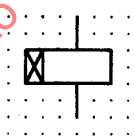
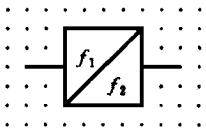
Sequence number	Symbol number	Graphical symbols	Name/explanation	Remark
150	S00079	N	Neutral	
151	S00035		Plugs and sockets, multipole (single-line representation)	
152	S00038		Connector assembly	
153	S00297		Motor starter, general symbol	Special type of starter can be added in the general qualifying symbols within limit symbols
154	S00305		Operating device, general symbol, relay coil, general symbol	
155	S00311		Relay coil of a slow-releasing relay	
156	S00312		Relay coil of a slow-operating relay	
157	S01232		Frequency converter, changing from F1 to F2	

Table CC.2 – Graphical symbols for electrical equipment of machines (created symbols by this part) *(1 of 3)*

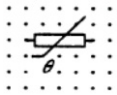
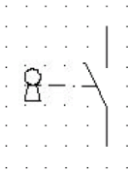
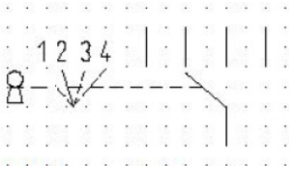
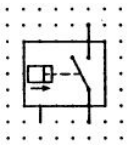
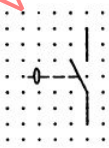
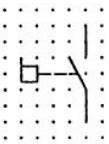
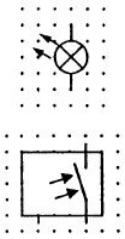
Sequence number	Symbol number	Graphical symbols	Name/explanation	Remark
1	-		Thermistor	
2	-		Key-operated switch	
3	-		Complex key-operated switch	
4	-		Pedal switch	
5	-		Pressure switch	3-wire system: 
6	-		Float switch	
7	-		Flow switch	
8	-		Photoelectric switch: transmission-type	

Table CC.2 *(2 of 3)*

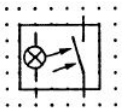
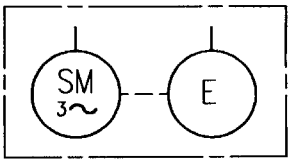
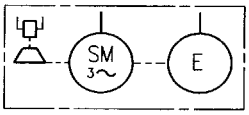
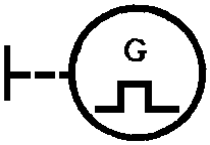
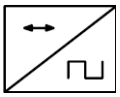
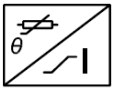
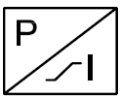
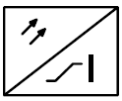
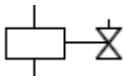
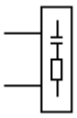
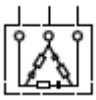
Sequence number	Symbol number	Graphical symbols	Name/explanation	Remark
9	-		Photoelectric switch: reflect-type	
10			Three-phase AC servo motor with position encoder	
11			Three-phase AC servo motor with position encoders and electromagnetic brake	
12			Hand pulse generator	
13			Position encoder	
14	-		Angle encoder; Angle position converts to 1vpp signal	Symbol '~' replaced by '⊓⊔',meaning is TTL signal.
15			Linear encoder; Linear position converts to TTL signal	Symbol '⊓⊔' replaced by '~',meaning is 1vpp signal.
16			Analog sensor: Temperature sensor: Temperature convert to analog current signal	Letter 'I' denotes current signal,if replaced by 'U',it denotes voltage signal,
17			Analog sensor: Pressure sensor: Pressure convert to analog current signal	
18			Analog sensor: Light sensor: Measuring distance convert to analog current signal	

Table CC.2 *(3 of 3)*

Sequence number	Symbol number	Graphical symbols	Name/explanation	Remark
19			Solenoid Valve	
20			Conductor Joint In-line splice	
21			Surge suppressor (1Phase)	
22			Surge suppressor (3Phase)	

Annex DD
(informative)

Reference designations for electrical diagrams of machine tools (derived from IEC 81346-2:2009)

Table DD.1 is derived from the Table 1 of IEC 81346-2:2009. Some examples of typical electrical products for machine tools are added to the Table. The purpose of Annex DD provides particular information related to machine tools. It should be taken into consideration that the actual information in the latest edition of IEC 81346-2 can be different and should be followed.

NOTE Differences between Table 1 of IEC 81346-2:2009 and Table DD.1 are underlined.

Table DD.1 – Classes of objects according to their intended purpose or task *(1 of 6)*

Code	Intended purpose or task of object	Examples of terms describing the intended purpose or task of objects	Examples of typical electrical components
A	Two or more purposes or tasks NOTE This class is only for objects for which no main intended purpose or task can be identified.		Touch screen
B	Converting an input variable (physical property, condition or event) into a signal for further processing	Detecting Measuring (picking-up of values) Monitoring Sensing Weighing (picking-up of values)	Current transformer Measuring relay Measuring shunt (resistance) Microphone Movement detector Overload relay Photocell Position switch Proximity sensor Proximity switch Smoke sensor Tachometer Temperature sensor Voltage transformer
C	Storing of energy, information or material	Recording Storing	Buffer battery Capacitor Event recorder (mainly for storing purposes) Hard disk Magnetic tape recorder (mainly for storing purposes) Memory RAM Storage battery Video recorder (mainly for storing purposes) Voltage recorder (mainly for storing purposes)
D	Reserved for future standardization		

Table DD.1 *(2 of 6)*

Code	Intended purpose or task of object	Examples of terms describing the intended purpose or task of objects	Examples of typical electrical components
E	Providing radiant or thermal energy	Cooling Heating Lighting Radiating	Electrical heater Electrical radiator Fluorescent lamp Lamp (LED Lamp for lighting) Lamp bulb Laser Luminaire Maser
F	Direct protection (selfacting) of a flow of energy, signals, personnel or equipment from dangerous or unwanted conditions Including systems and equipment for protective purposes	Absorbing Guarding Preventing Protecting Securing Shielding	Cathodic protection anode Faraday cage Fuse Miniature circuit-breaker Surge arrester Thermal overload release
G	Initiating a flow of energy or material Generating signals used as information carriers or reference source	Generating	Dry cell battery Dynamo Fuel cell Generator Rotating generator Signal generator Solar cell Wave generator
H	Producing a new kind of material or product		
I	Not to be applied	---	---
J	Reserved for future standardization		

Table DD.1 *(3 of 6)*

Code	Intended purpose or task of object	Examples of terms describing the intended purpose or task of objects	Examples of typical electrical components
K	Processing (receiving, treating and providing) signals or information (excluding objects for protective purposes, see Class F)	Closing (of control circuits) Continuous controlling Delaying Opening (of control circuits) Postponing Switching (of control circuits) Synchronizing	NC CNC PLC All-or-nothing relay Analogue integrated circuit Binary integrated circuit Contactor relay CPU Delay line Electronic valve Electronic tube Feedback controller Filter, a.c. or d.c. Microprocessor Programmable controller Synchronizing device Time relay Transistor Solenoid valve
L	Reserved for future standardization		
M	Providing mechanical energy (rotational or linear mechanical motion) for driving purposes	Actuating Driving	Actuating coil Actuator Electric motor Linear motor
N	Reserved for future standardization		
O	Not to be applied	---	---

Table DD.1 *(4 of 6)*

Code	Intended purpose or task of object	Examples of terms describing the intended purpose or task of objects	Examples of typical electrical components
P	Presenting information	Alarming Communicating Displaying Indicating Informing Measuring (presentation of variables) Presenting Printing Warning	Ammeter Bell Clock Continuous line recorder Event counter Geiger counter LED Loudspeaker Printer Recording voltmeter (mainly for presentation purposes) Signal lamp Signal vibrator Synchroscope Text display Voltmeter Wattmeter Watt-hour meter
Q	Controlled switching or varying a flow of energy, of signals (for signals in control circuits, see Classes K and S) or of material	Opening (of energy, signals and material flow) Closing (of energy, signals and material flow) Switching (of energy, signals and material flow Clutching)	Circuit-breaker Contactor (for power) Disconnector Fuse switch (if main purpose is protection, see Class F) Fuse-switch-disconnector (if main purpose is protection, see Class F) Motor starter Power transistor Thyristor
R	Restricting or stabilizing motion or a flow of energy, information or material	Blocking Damping Restricting Limiting Stabilizing	Diode Inductor Limiter Resistor
S	Converting a manual operation into a signal for further processing	Influencing Manually controlling Selecting	Control switch Cordless mouse Discrepancy switch Keyboard Light pen Push-button switch Selector switch Set-point adjuster

Table DD.1 *(5 of 6)*

Code	Intended purpose or task of object	Examples of terms describing the intended purpose or task of objects	Examples of typical electrical components
T	Conversion of energy maintaining the kind of energy Conversion of an established signal maintaining the content of information Conversion of the form or shape of a material	Amplifying Modulating Transforming Casting Compressing Converting Cutting Material deforming Expanding Forging Grinding Rolling Size enlargement Size reduction Turning	AC/DC converter Aerial Amplifier Electrical transducer Frequency convertor Power transformer Rectifier Signal converter Servo drive unit
U	Keeping objects in a defined position	Bearing Carrying Holding Supporting	Insulator
V	Processing (treating) of material or products (including preparatory and post-treatment)	Coating Cleaning Dehydrating Derusting Drying Filtering Heat treatment Packing Preconditioning Recovering Re-finishing Sealing Separating Sorting Stirring Surface treatment Wrapping	

Table DD.1 *(6 of 6)*

Code	Intended purpose or task of object	Examples of terms describing the intended purpose or task of objects	Examples of typical electrical components
W	Guiding or transporting energy, signals, material or products from one place to another	Conducting Distributing Guiding Leading Positioning Transporting	Busbar Bushing Cable Conductor Data bus Optical fibre
X	Connecting objects	Connecting Coupling Joining	Connector Hub Plug connector Terminal Terminal block Terminal strip
Y	Reserved for future standardization		
Z	Reserved for future standardization		

Annex EE
(informative)

Examples and short specifications (briefing) of electrical diagrams

EE.1 General

According to the requirements of Clause 18 of IEC 60204-1:—, the basic information (technical documentation) of operation and maintenance of machine tools and electrical equipment should contain electrical diagrams, specifications, etc. Annex EE gives examples of documentation for machine tools, including circuit diagrams and parts layout diagrams.

Annex EE is intended not to show the examples as documentation but the example of function or circuit itself. And the examples of diagram are not related to each other. Refer to the relative standards (ex. IEC 61082-1, etc) mentioned in Clause 18 of IEC 60204-1:— for details of documentation. Manufacturers of machine tools should provide the necessary documentations.

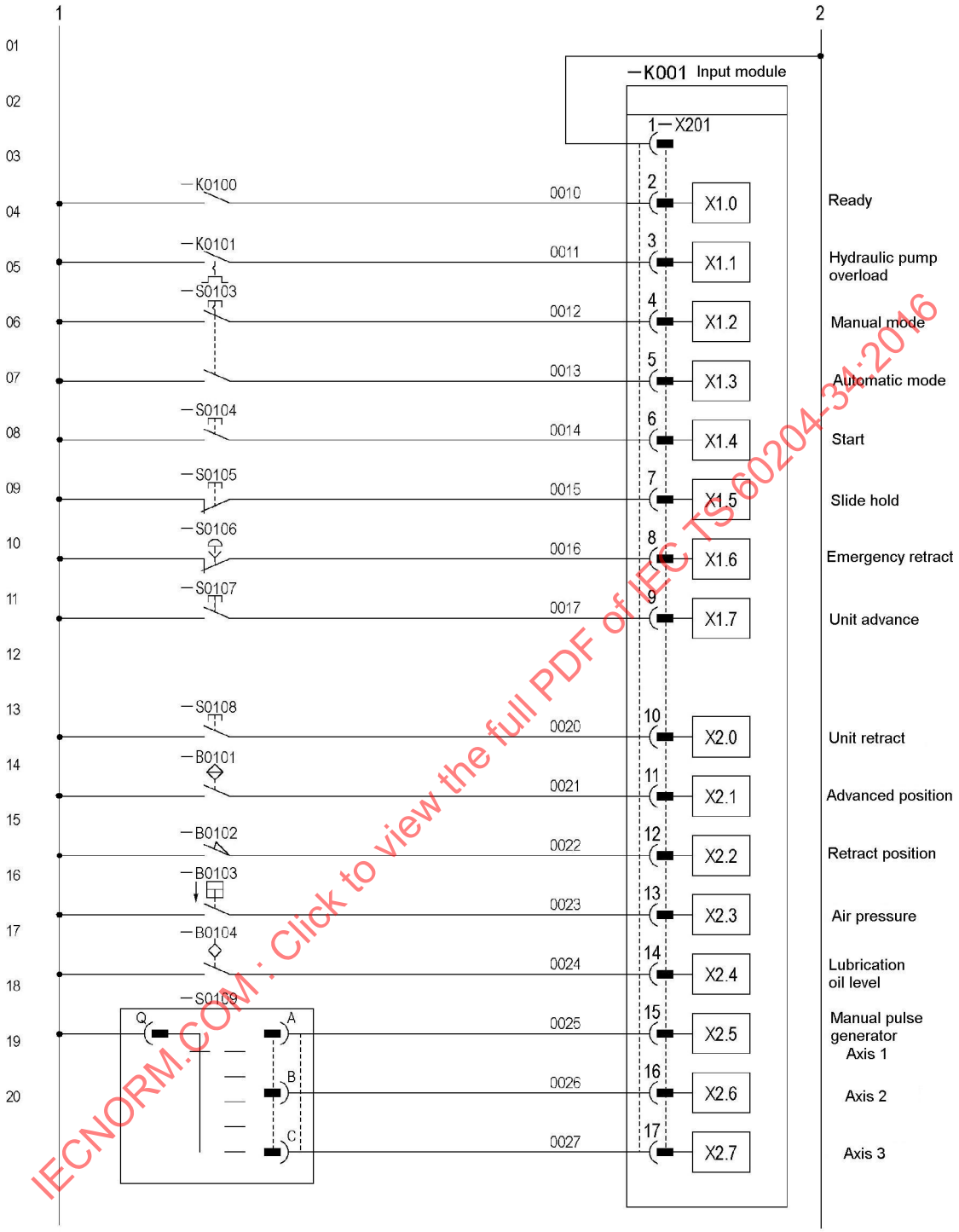
EE.2 Examples of diagram

The following diagrams show examples, and the examples of diagrams are not related to each other.

Figure EE.1 to Figure EE.5 show examples of circuit diagrams. This circuit diagram and the graphical symbols may be rotated and/or mirrored.

Figure EE.6 shows an example of arrangement diagram of electric elements on switchboard.

Figure EE.7 shows an example of arrangement drawing.



—S0109 Contact position

Position	Terminal		
	A	B	C
OFF			
X	+		
Y		+	
Z	+	+	
4			+

IEC

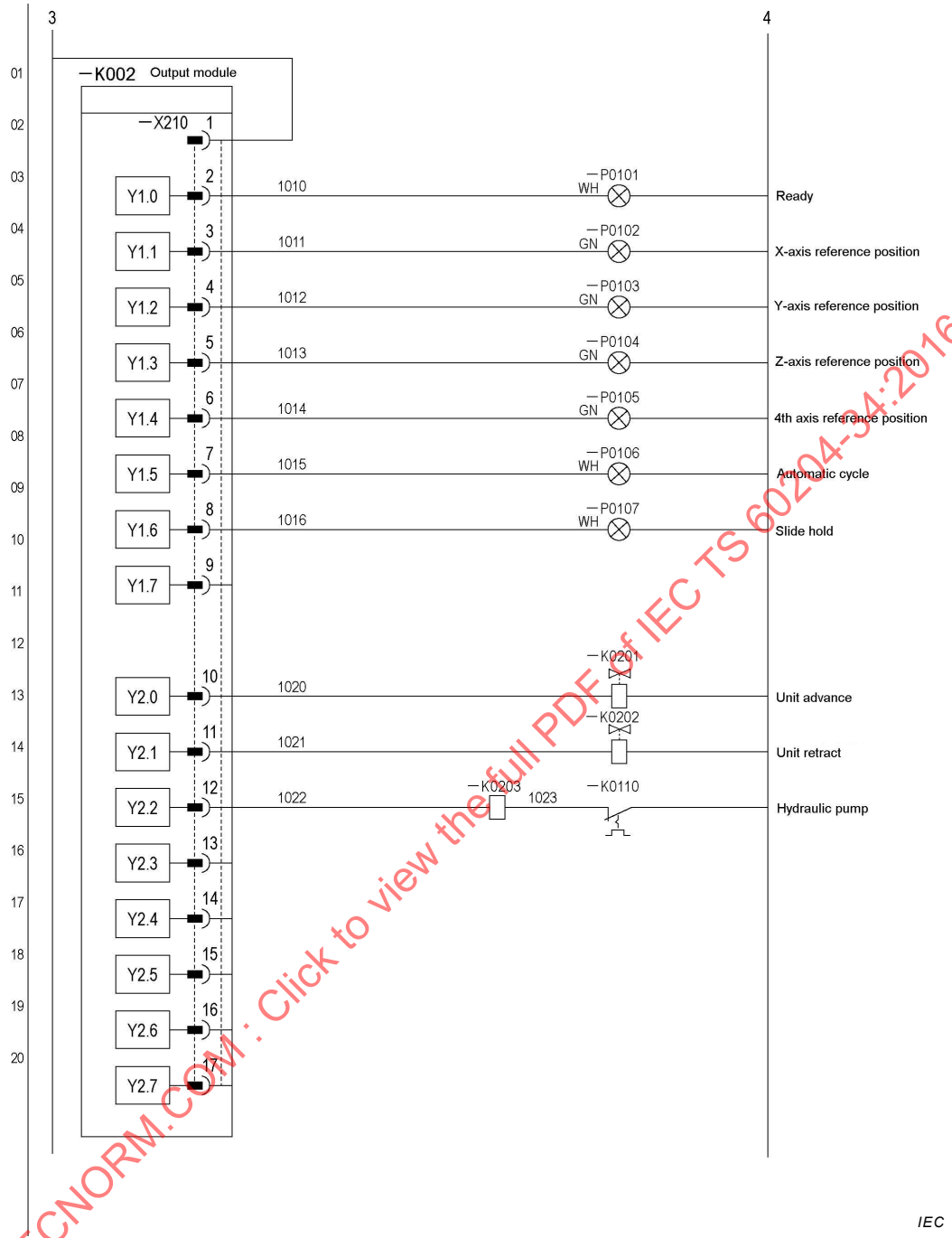


Figure EE.1 – Circuit diagram (1)

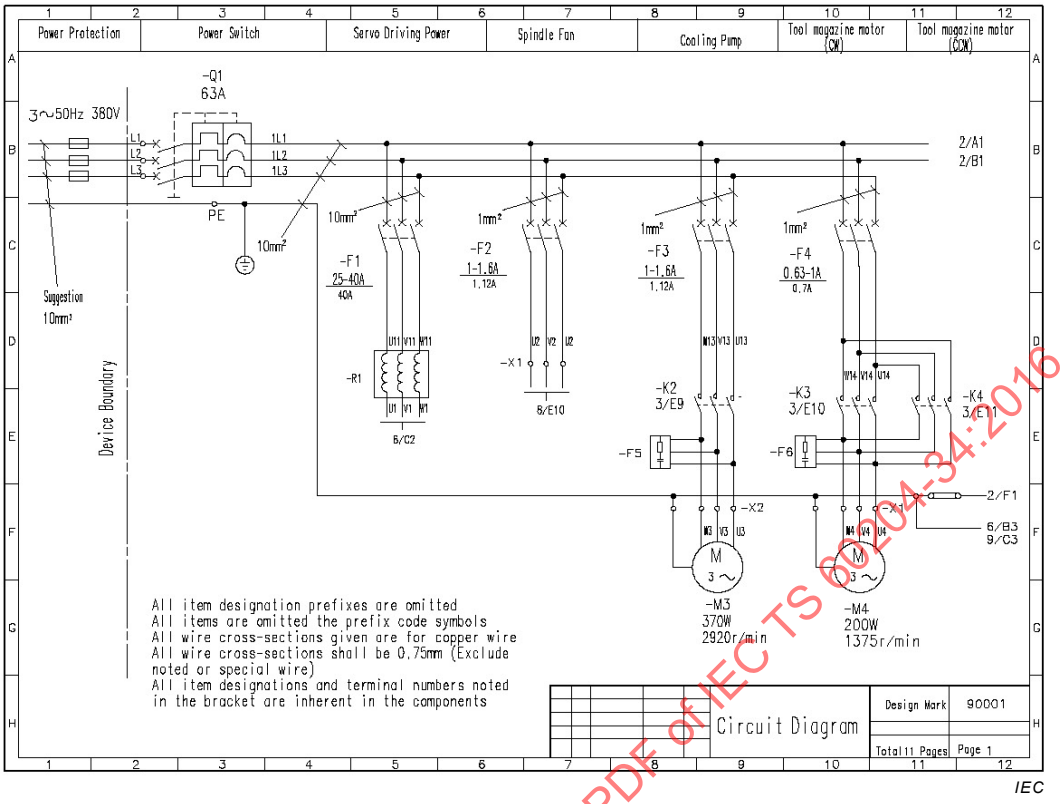


Figure EE.2 – Circuit diagram (2)

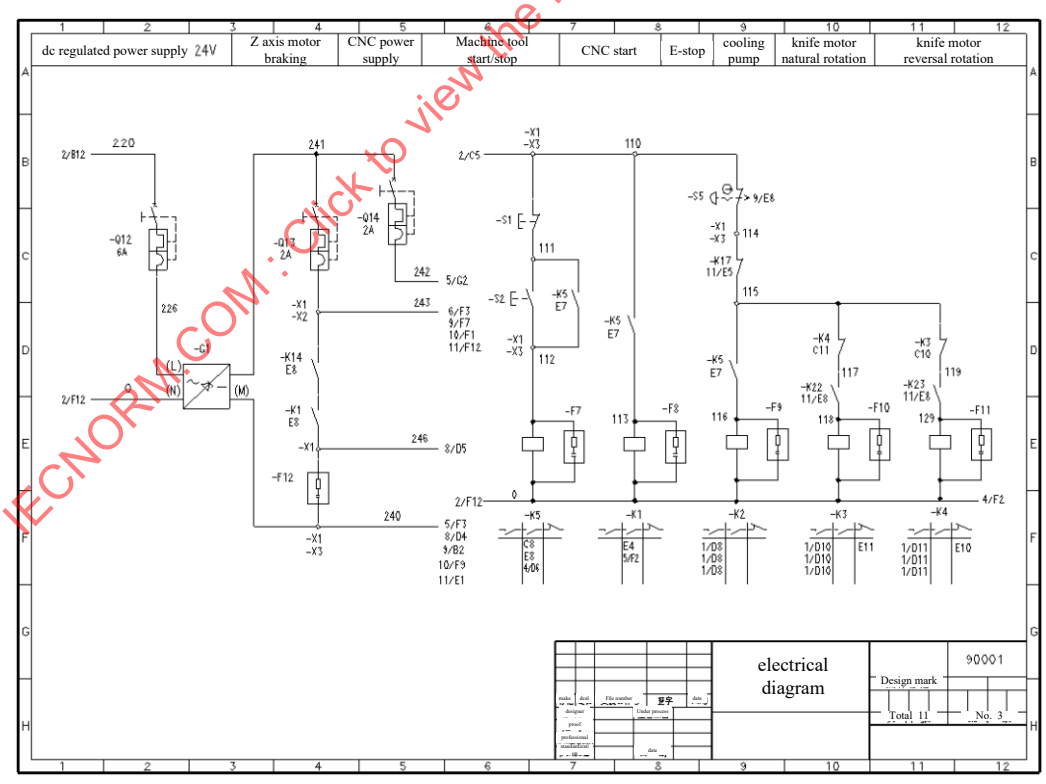


Figure EE.3 – Circuit diagram (3)

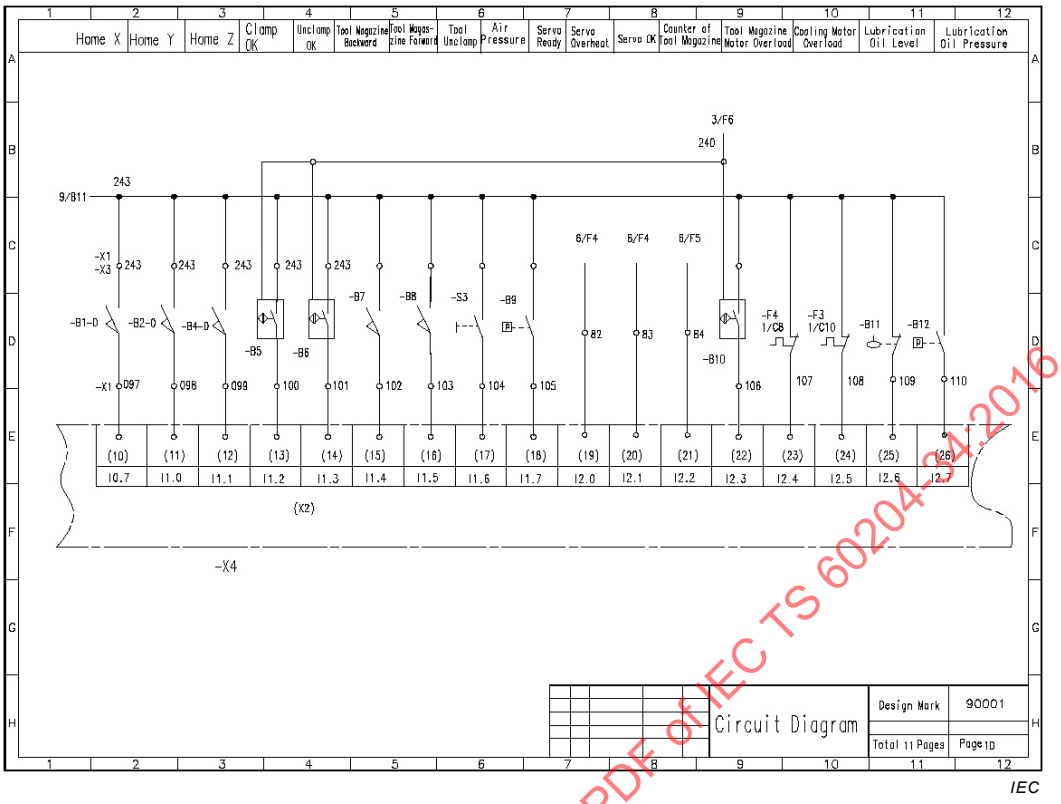


Figure EE.4 – Circuit diagram (4)

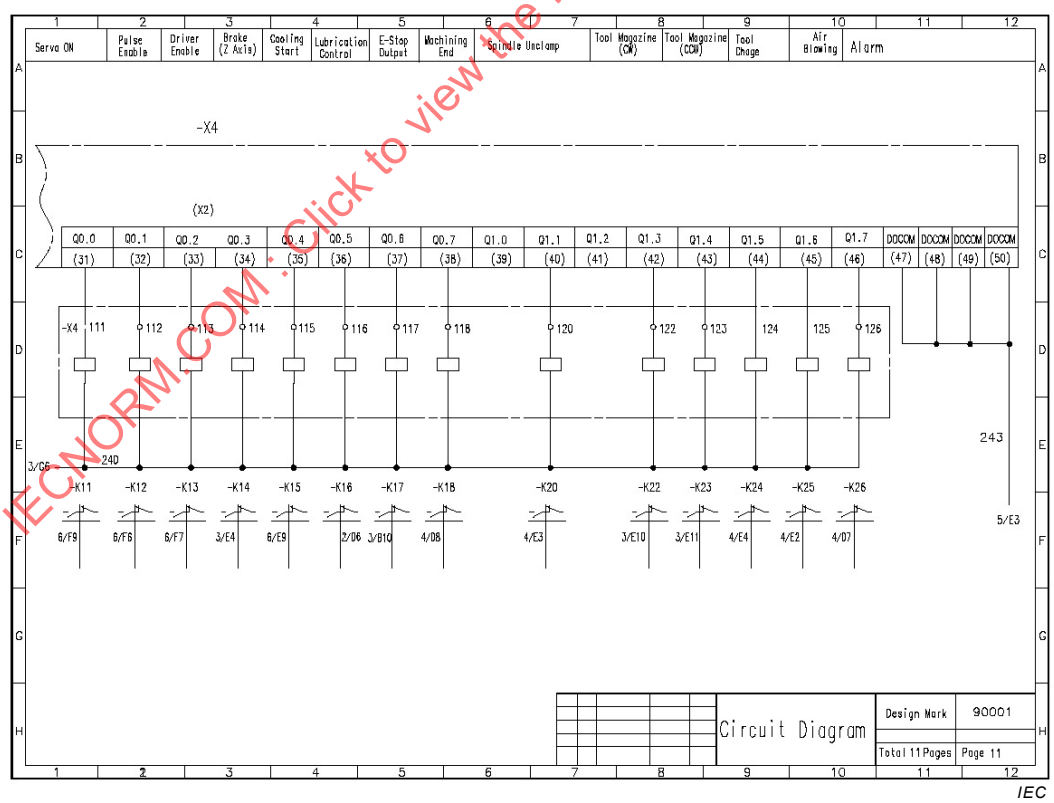


Figure EE.5 – Circuit diagram (5)

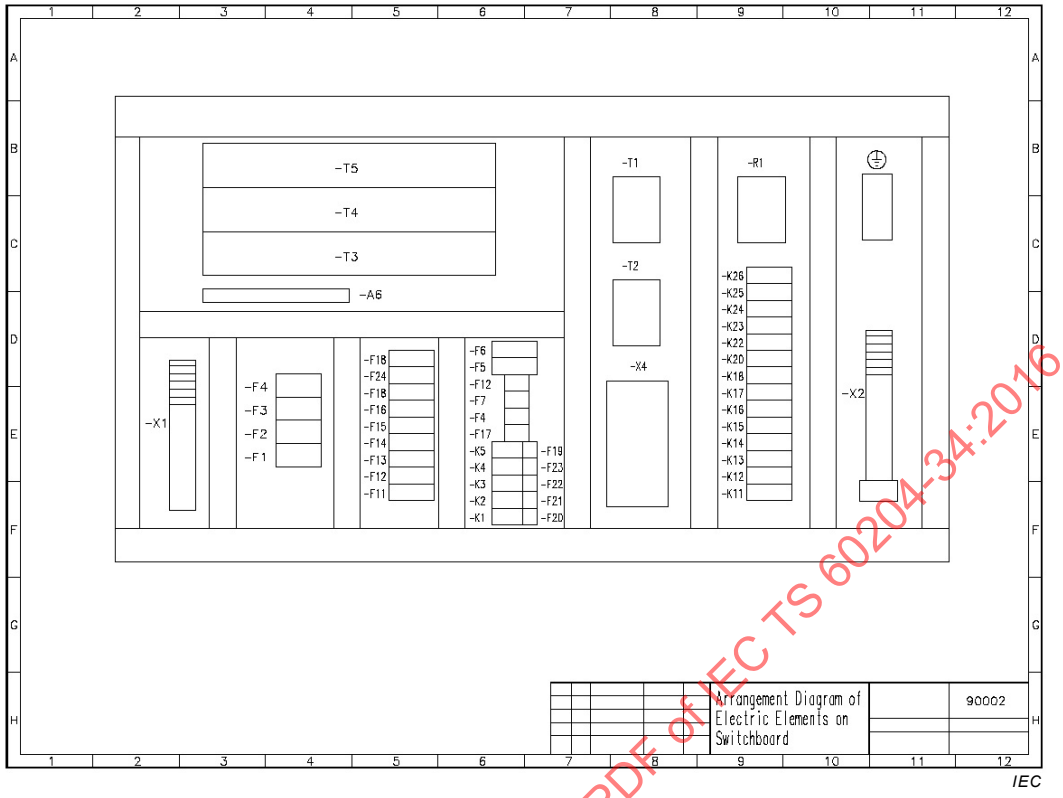


Figure EE.6 – Arrangement diagram of electric elements on switchboard

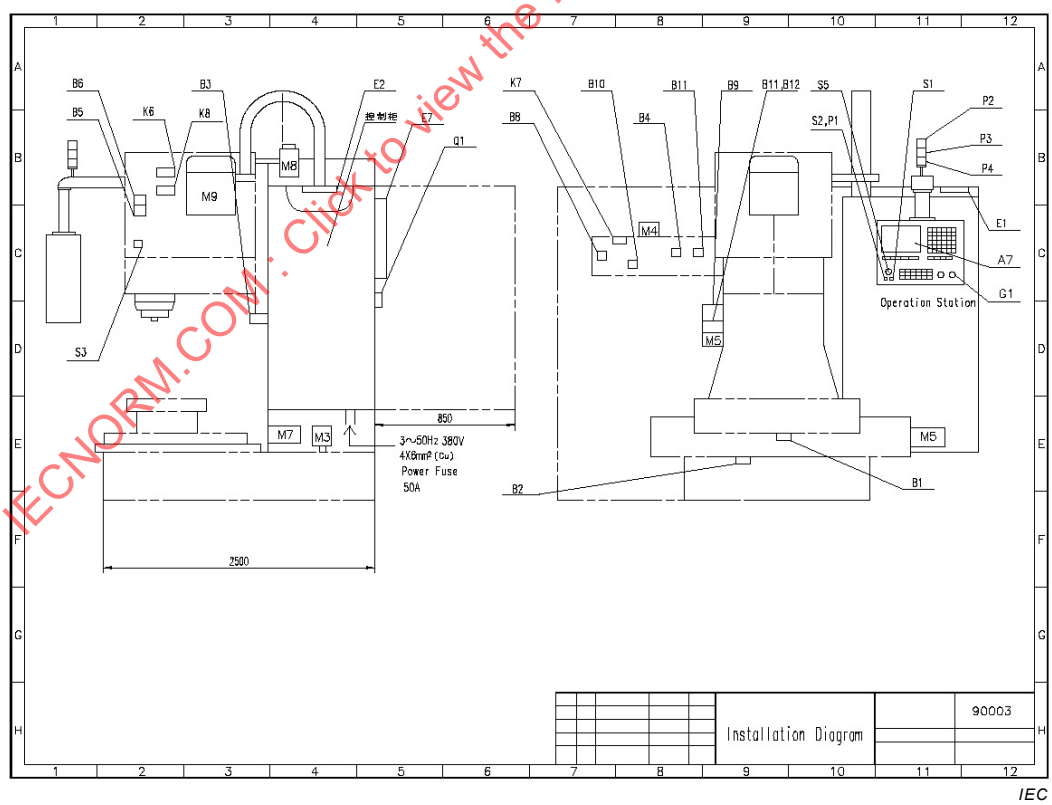


Figure EE.7 – Arrangement drawing

Annex FF
(informative)

Safety related standards for components or units

Annex FF shows the standards, that the components and units assembled in machine tools should comply with. Because kinds and usage of the components used in machine tools are various, the standards which should be complied with are not limited to Table FF.1.

Table FF.1 – Standards related to components or units *(1 of 22)*

No.	Component	Relevant Standard		Electrical /Mechanical /EMC component aspects	Remarks for safety application	General Remarks
1	**Circuit-breaker**					
1.1	Circuit-breaker	IEC 60947-2	Low-voltage switchgear and controlgear – Part 2: Circuit-breakers	O / - / -		See 5.3.2 c) of IEC 60204-1: — (isolation requirements)
1.2	Residual Current Device (RCD)	IEC 60947-2	Low-voltage switchgear and controlgear – Part 2: Circuit-breakers	O / - / O		
1.3	Operation handle for supply disconnect device	IEC 60947-2	Low-voltage switchgear and controlgear – Part 2: Circuit-breakers	O / – / –		
1.4		IEC 60204-1	Safety of machinery – Electrical equipment of machines – Part 1: General requirements	– / O / –	Operating means is provided with a means permitting it to be locked in the OFF (isolated) position.	See 5.3.3 and 5.3.4 of IEC 60204-1: —.
1.5	Circuit protector	IEC 60934	Circuit-breakers for equipment (CBE)	O / – / –		
1.6	Auxiliary contact for circuit-breaker	IEC 60947-5-1	Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices	O / – / –		
1.7	Under - voltage release coil unit	IEC 60947-2	Low-voltage switchgear and controlgear – Part 2: Circuit-breakers	O / – / –		
2	**Electromechanical contactor**					
2.1	Electromechani-cal contactor	IEC 60947-4-1	Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters	O / O / –	The auxiliary contact is used as a mirror contact to monitor the open state of the main contacts.	See Annex F of IEC 60947-4-1 :2009 and IEC 60947-4-1 :2009/AMD1: 2012 for mirror contacts.

Table FF.1 *(2 of 22)*

No.	Component	Relevant Standard		Electrical /Mechanical /EMC component aspects	Remarks for safety application	General Remarks
2.2	Thermal overload relay	IEC 60947-4-1	Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters	O / - / -		
2.3	Electromechanical motor starter	IEC 60947-4-1	Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters	O / O / –	The auxiliary contact is used as a mirror contact to monitor the open state of the main contacts.	See Annex F of IEC 60947-4-1:2009 and IEC 60947-4-1:2009/AMD 1:2012 for mirror contacts.
2.4	Auxiliary contact for electromechanical contactor	IEC 60947-5-1	Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices	O / O / –	The auxiliary N.C. contact is used as a mechanically linked contact to monitor the open state of the N.O. contact.	See Annex L of IEC 60947-5-1:2003 and IEC 60947-5-1:2003/AMD 1:2009 for mechanically linked contact.
2.5	AC semiconductor contactors	IEC 60947-4-2	Low-voltage switchgear and controlgear – Part 4-2: Contactors and motor-starters – AC semiconductor motor controllers and starters	O / – / –		
2.6	DC semiconductor contactors	IEC 60947-4-3	Low-voltage switchgear and controlgear – Part 4-3: Contactors and motor-starters – AC semiconductor controllers and contactors for non-motor loads	O / – / –		

Table FF.1 *(3 of 22)*

No.	Component	Relevant Standard		Electrical /Mechanical /EMC component aspects	Remarks for safety application	General Remarks
3	**Relays**					
3.1	Relay	IEC 61810-1	Electromechanical elementary relays – Part 1: General requirements	O / – / –		
3.2		IEC 60947-5-1	Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices	- / O / –	The auxiliary N.C. contact is used as a mechanically linked contact to monitor the open state of the N.O. contact.	See Annex L of IEC 60947-5-1:2003 and IEC 60947-5-1:2003/AMD 1:2009 for mechanically linked contact.
3.3	Solid state relay	IEC 60950-1	Information technology equipment – Safety – Part 1: General requirements	O / – / –		
3.4	Socket for relay	IEC 61810-1	Electromechanical elementary relays – Part 1: General requirements	O / – / –		
3.5		IEC 61984	Connectors – Safety requirements and tests	O / – / –		
4	**Timer, Counter**					
4.1	Timer	IEC 61812-1	Time relays for industrial and residential use – Part 1: Requirements and tests	O / – / –		
4.2		IEC 61000-6-2	Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments	– / – / O		
4.3		IEC 61000-6-4	Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments	– / – / O		

Table FF.1 *(4 of 22)*

No.	Component	Relevant Standard		Electrical /Mechanical /EMC component aspects	Remarks for safety application	General Remarks
4.4	Counter	IEC 61000-6-2	Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments	– / – / O		
4.5		IEC 61000-6-4	Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments	– / – / O		
5	**operation switches**					
5.1	Push button	IEC 60947-5-1	Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices	O / – / –		
5.2	Emergency stop device	IEC 60947-5-1	Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices	O / O / –	Direct opening action is provided for contacts	See Annex K of IEC 60947-5-1:2003 and IEC 60947-5-1:2003/AMD 1:2009 for direct opening action.
5.3		IEC 60947-5-5	Low-voltage switchgear and controlgear – Part 5-5: Control circuit devices and switching elements – Electrical emergency stop device with mechanical latching function	– / O / –	Latching function is provided for contacts.	See also 7.1.4.5 of IEC 60947-5-1:2003 and IEC 60947-5-1:2003/AMD 1:2009 for latching function.
5.4		ISO 13849-1	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design	– / O / –	The following safety related component data are relevant to evaluate safety functions (B10d)	See 9.4 of IEC 60204-1: —

Table FF.1 *(5 of 22)*

No.	Component	Relevant Standard		Electrical /Mechanical /EMC component aspects	Remarks for safety application	General Remarks
5.5		IEC 62061	Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems	– / O / –	The following safety related component data are relevant to evaluate safety functions (B10)	See 9.4 of IEC 60204-1: —
5.6	Selector switch	IEC 60947-5-1	Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices	O / – / –		
5.7	Key operated selector switch	IEC 60947-5-1	Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices	O / – / –		
5.8	Toggle switch	IEC 60947-5-1	Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices	O / – / –		
5.9	Enabling device	IEC 60947-5-8	Low-voltage switchgear and controlgear – Part 5-8: Control circuit devices and switching elements – Three-position enabling switches	O / – / –		
5.10		ISO 13849-1	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design	– / O / –	The following safety related component data are relevant to evaluate safety functions (B10d)	See 9.4 of IEC 60204-1: —

Table FF.1 *(6 of 22)*

No.	Component	Relevant Standard		Electrical /Mechanical /EMC component aspects	Remarks for safety application	General Remarks
5.11		IEC 62061	Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems	– / O / –	The following safety related component data are relevant to evaluate safety functions (B10)	See 9.4 of IEC 60204-1: —
5.12	Two-hand control device	IEC 60947-5-1	Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices	O / – / –		
5.13		ISO 13851	Safety of machinery – Two-hand control devices – Functional aspects and design principles	– / O / –		
5.14		ISO 13849-1	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design	– / O / –	The following safety related component data are relevant to evaluate safety functions (B10d)	See 9.4 of IEC 60204-1: —
5.15		IEC 62061	Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems	– / O / –	The following safety related component data are relevant to evaluate safety functions (B10)	See 9.4 of IEC 60204-1: –
5.16	Indicator lamp	IEC 60947-5-1	Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices	O / – / –		
5.17	Status lamp	IEC 60598-1	Luminaires – Part 1: General requirements and tests	O / – / –		

Table FF.1 *(7 of 22)*

No.	Component	Relevant Standard		Electrical /Mechanical /EMC component aspects	Remarks for safety application	General Remarks
6	**HMI**					
6.1	Operator panel	IEC 61131-2	Programmable controllers – Part 2: Equipment requirements and tests	O / – / O		
6.2		IEC 61010-2-201	Safety requirements for electrical equipment for measurement, control and laboratory use – Part 2-201: Particular requirements for control equipment	O / – / –		As appropriate
6.3		IEC 61131-6	Programmable controllers – Part 6: Functional safety	– / O / O	Required only if a safety related part determined by the risk of assessment made or in accordance with the relevant type-C standard for functional safety.	
7	**CNC control**					
7.1	CNC control		Electronic equipment for use in power installations	O / – / –		
7.2		IEC 61508 series	Functional safety of electrical/electronic/programmable electronic safety-related systems	– / O / –	This standard is applied only for CNC control with declaration of SIL level. The following safety related component data are relevant to evaluate safety functions (SIL and PFH_D)	See Note 2 of the scope of IEC 62061: 2005 and IEC 62061: 2005/AMD1: 2012.
7.3		IEC 62061	Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems	– / O / –	This standard is applied only for CNC control with declaration of SIL level. The following safety related component data are relevant to evaluate safety functions (SIL and PFH_D)	See 9.4 of IEC 60204-1: —

Table FF.1 *(8 of 22)*

No.	Component	Relevant Standard		Electrical /Mechanical /EMC component aspects	Remarks for safety application	General Remarks
7.4		ISO 13849-1	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design	– / O / –	This standard is applied only for CNC control with declaration of PL level. The following safety related component data are relevant to evaluate safety functions (PL, PFH_D and/or Category)	See 9.4 of IEC 60204-1: —
7.5		IEC 61000-6-2	Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments	– / – / O		
7.6		IEC 61000-6-4	Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments	– / – / O		
7.7		IEC 61131-2	Programmable controllers – Part 2: Equipment requirements and tests	O / – / O		This standard can be applied to CNC control in substitution for 7.1, 7.4 and 7.5 of this Table.
7.8		IEC 61010-2-201	Safety requirements for electrical equipment for measurement, control and laboratory use – Part 2-201: Particular requirements for control equipment	O / – / –		As appropiate
8	**Electronic equipment for use in power installations**					
8.1	Electronic equipment for use in power installations		Programmable controllers – Part 2: Equipment requirements and tests Electronic equipment for use in power installations	O / – / –		

Table FF.1 *(9 of 22)*

No.	Component	Relevant Standard		Electrical /Mechanical /EMC component aspects	Remarks for safety application	General Remarks
8.2		IEC 61000-6-2	Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments	– / – / O		
8.3		IEC 61000-6-4	Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments	– / – / O		
9	Encoder (Linear/Rotary)					
9.1	Encoder (Linear/Rotary)	IEC 61000-6-2	Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments	– / – / O		
9.2		IEC 61000-6-4	Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments	– / – / O		
10	**Programmable controller**					
10.1	Programmable controller	IEC 61131-1	Programmable controllers – Part 1: General information	O / – / -	See 21.8 of this Table for safety programmable controllers.	
10.2		IEC 61131-2	Programmable controllers – Part 2: Equipment requirements and tests	O / – / O		
10.3		IEC 61010-2-201	Safety requirements for electrical equipment for measurement, control and laboratory use – Part 2-201: Particular requirements for control equipment	O / – / –		As appropriate

Table FF.1 *(10 of 22)*

No.	Component	Relevant Standard		Electrical /Mechanical /EMC component aspects	Remarks for safety application	General Remarks
11	**Power Drive System**					
11.1	Power Drive System	IEC 61800-5-1	Adjustable Speed Electrical Power Drive System – Part 5-1:Safety Requirements – Electrical, Thermal And Energy	O / – / –		
11.2		IEC 61800-5-2	Adjustable speed electrical power drive systems –Part 5-2:Safety requirements – Functional	– / O / –	This standard is applied only for safety PDS.	
11.3		IEC 62061	Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems	– / O / –	This standard is applied only for safety PDS. The following safety related component data are relevant to evaluate safety functions (SIL and PFH_D)	See 9.4 of IEC 60204-1: —
11.4		ISO 13849-1	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design	– / O / –	This standard is applied only for safety PDS. The following safety related component data are relevant to evaluate safety functions (PL, PFH_D and/or Category)	See 9.4 of IEC 60204-1: —
11.5		IEC 61800-3	Adjustable speed electrical power drive systems – Part 3: EMC requirements and specific test methods	– / – / O		