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Industrial automation systems and integration — Numerical control systems for machine tools —

Part 1: Requirements for numerical control systems

Systèmes d'automatisation et intégration — Systèmes de commandes numériques des machines-outils —

Partie 1: Exigences relatives aux systèmes de commandes numériques

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 184, *Automation systems and integration*, Subcommittee SC 1, *Industrial cyber and physical device control*.

A list of all parts in the ISO 23218 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Numerically controlled machine tools are effective production assets with an operations stock of more than four million units and still increasing.

While mechanical construction sets the base for accuracy and durability, the numerical control system (NC system) enables the leverage the potential of the system.

The NC system comprises a powerful computing hardware, a sophisticated NC-Kernel, and an elaborated connectivity, stretching from internal process parameters to high level manufacturing execution systems (MES) integration and beyond. It supports operation concepts from push buttons to sophisticated touch-panel systems.

Machine tools and their NC systems are used in harsh environments facing operational conditions, such as vibrations, dirt, coolant spray and electromagnetic interference. Purchasers and operators of machine tools require confidence in the appropriate quality, durability and usability in order to ensure the intended use and productivity.

The ISO 23218 series addresses requirements for the NC systems. This document specifically provides requirements for the NC system itself, and ISO 23218-2[1)] provides requirements for NC system integration.

Expected users of this document include:

— design engineers working for an NC system company for machine tools, for developing a new and/or improving a current NC system for machine tools;

— design engineers working for a machine tool builder company, for developing and providing new and/or improving current machine tools by procuring an NC system;

— facility planning engineers, for procuring new and/or improving current machine tools with an NC system.

1) Under preparation. Stage at the time of publication: ISO/FDIS 23218-2.

Industrial automation systems and integration — Numerical control systems for machine tools —

Part 1: Requirements for numerical control systems

1 Scope

This document specifies general requirements for the design and manufacturing of numerical control systems (NC systems) for machine tools. It consists of technical and inspection requirements and test methods.

This document is applicable to NC systems used in machine tools (including metal cutting machine tools, metal forming machine tools and woodworking machine tools) and to partial assemblies of machine tools (including cabinets and auxiliary devices) intended to be integrated into machine tools. It is also applicable to other production equipment using NC systems.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies

ISO 780, *Packaging — Distribution packaging — Graphical symbols for handling and storage of packages*

ISO 841, *Industrial automation systems and integration — Numerical control of machines — Coordinate system and motion nomenclature*

ISO 2806, *Industrial automation systems — Numerical control of machines — Vocabulary*

ISO 6983-1, *Automation systems and integration — Numerical control of machines — Program format and definitions of address words — Part 1: Data format for positioning, line motion and contouring control systems*

ISO 10303-238, *Industrial automation systems and integration — Product data representation and exchange — Part 238: Application protocol: Model based integrated manufacturing*

ISO 14649 (all parts), *Industrial automation systems and integration — Physical device control — Data model for computerized numerical controllers*

IEC 60068-2-1:2007, *Environmental testing — Part 2-1: Tests — Test A: Cold*

IEC 60068-2-2:2007, *Environmental testing — Part 2-1: Tests — Test B Dry heat*

IEC 60068-2-6:2007, *Environmental testing — Part 2-6: Tests — Test Fc: Vibration (sinusoidal)*

IEC 60068-2-14:2009, *Environmental testing — Part 2-14: Tests — Test N: Change of temperature*

IEC 60068-2-27:2008, *Environmental testing — Part 2-27: Tests — Test Ea and guidance: Shock*

IEC 60068-2-31:2008, *Environmental testing — Part 2-31: Tests — Test Ec: Rough handling shocks, primarily for equipment-type specimens*

IEC 60068-2-78:2012, *Environmental testing — Part 2-78: Tests — Test Cab: Damp heat, steady state*

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

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) — Part 4-2: Testing and measurement techniques — Electrostatic discharge immunity test*

IEC 61000-4-3:2020, *Electromagnetic compatibility (EMC) — Part 4-3: Testing and measurement techniques — Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4:2012, *Electromagnetic compatibility (EMC) — Part 4-4: Testing and measurement techniques — Electrical fast transient/burst immunity test*

IEC 61000-4-5:2014, *Electromagnetic compatibility (EMC) — Part 4-5: Testing and measurement techniques — Surge immunity test*

IEC 61000-4-6:2013, *Electromagnetic compatibility (EMC) — Part 4-6: Testing and measurement techniques — Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8:2009, *Electromagnetic compatibility (EMC) — Part 4-8: Testing and measurement techniques — Power frequency magnetic field immunity test*

IEC 61000-4-11:2020, *Electromagnetic compatibility (EMC) — Part 4-11: Testing and measurement techniques — Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-6-2, *Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity for industrial environments*

IEC 61800-3:2017, *Adjustable speed electrical power drive systems — Part 3: EMC requirements and specific test methods*

IEC 82079-1, *Preparation of instructions for use — Structuring, content and presentation — Part 1: General principles and detailed requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2806 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
numerical control system
NC system
system that realizes the automatic control of a process by the use of numerical data introduced while the operation is in progress

Note 1 to entry: Driving devices are not included in NC systems.

3.2
port
access to a device or network of the *numerical control (NC) system* (3.1) where electromagnetic energy or signals may be supplied or received or where the device or network variables may be observed or measured

Note 1 to entry: The port generally refers to the boundary on the external interface of the numerical control (NC) system, and interface generally refers to the boundary of each unit in NC system.

[SOURCE: IEC 60050-131:2002, 131-12-60, modified]

3.3
enclosure port
physical boundary of the *numerical control (NC) system* (3.1) through which electromagnetic fields can radiate or impinge

3.4
power port
port (3.2) which connects a *numerical control (NC) system* (3.1) to a power supply, which usually includes a protection grounding port

Note 1 to entry: Power output port of a driver unit connecting to motor is the motor power interface.

[SOURCE: IEC 60050-131:2002, 131-12-60, modified]

3.5
signal interfaces of control and measurement
control and measurement signal interface between a device and unit of the *numerical control (NC) system* (3.1)

Note 1 to entry: Interfaces are connected with a signal line or signal cable to perform a specified function(s).

3.6
computer signal port
signal port
port between each device of the *numerical control (NC) system* (3.1) and computer(s), usually including ports of, e.g. RS232/485, USB, keyboard, network signal

3.7
second environment
environment that includes all establishments other than those directly connected to a low-voltage power supply network, which supplies buildings used for residential purposes

Note 1 to entry: Industrial areas or technical areas of any building fed from a dedicated transformer are examples of second environment locations.

[SOURCE: IEC 61800-3:2017, 3.2.3]

3.8
EMC
electromagnetic compatibility
ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

[SOURCE: IEC 60050-161:1990, 161-01-07]

3.9
immunity
<to disturbance> ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance

[SOURCE: IEC 60050-161:1990, 161-01-20]

3.10
electrostatic discharge
ESD
transfer of electric charge between bodies of different electrostatic potential in proximity or through direct contact

[SOURCE: IEC 60050-161:1990, 161-01-22]

3.11
electrical fast transient/burst
burst
sequence of a limited number of distinct pulses or an oscillation of limited duration

[SOURCE: IEC 60050-161:1990, 161-02-07]

3.12
transient, adj
pertaining to or designating a phenomenon or a quantity which varies between two consecutive steady-states during a time interval which is short compared with the time-scale of interest

[SOURCE: IEC 60050-161:1990, 161-02-01]

3.13
surge
transient (3.12) wave of electrical current, voltage or power propagating along a line or a circuit and characterized by a rapid increase followed by a slower decrease

[SOURCE: IEC 60050-161:1990, 161-08-11, modified]

3.14
voltage dip
sudden reduction of the voltage at a particular point of an electricity supply system below a specified dip threshold followed by its recovery after a brief interval

Note 1 to entry: Typically, a dip is associated with the occurrence and termination of a short circuit or other extreme current increase on the system or installations connected to it.

Note 2 to entry: A voltage dip is a two-dimensional electromagnetic disturbance, the level of which is determined by both voltage and time (duration).

[SOURCE: IEC 61000-4-11:2020, 3.3]

3.15
conducted disturbance
electromagnetic disturbance for which the energy is transferred via one or more conductors

[SOURCE: IEC 61050:1991, 3.20]

4 Abbreviated terms

AC	Alternating Current
CDN	Coupling/Decoupling Network
DC	Direct Current
EMC	Electromagnetic Compatibility
EMI	Electro-Magnetic Interference
ESD	Electrostatic Discharge
MTBF	Mean Time Between Failures
NC	Numerical Control
NCSUT	Numerical Control System Under Test
PELV	Protective Extra-Low Voltage

RCD	Residual Current protective Device
RF	Radio Frequency
SPD	Surge Protective Devices
SELV	Safe Extra-Low Voltage

5 Technical requirements

5.1 NC system functional requirements

5.1.1 Coordinate system and motion direction

Coordinate system and motion direction of the NC system shall be in accordance with ISO 841.

5.1.2 Programming languages

Programming languages used by the NC system should be in accordance with the relevant ISO standards, e.g. G codes (preparatory function codes) and M codes (miscellaneous function) shall be in accordance with ISO 6983-1, STEP-NC shall be in accordance with the ISO 14649 series and ISO 10303-238.

5.1.3 Control function of the NC system

Control functions of NC systems should be able to fulfil the control requirements of the machine tools controlled.

The control functions of the NC system shall be described in detail in the manual.

NC systems should have all relevant modes to fulfill the control requirements of the controlled machine tools, e.g.

— automatic operation,

— manual operation,

— manual data input (MDI),

— program input and editing,

— home return.

Special function requirements of the NC system can be specified between the supplier and user of the NC system.

5.2 Interface signals of NC systems

5.2.1 Analogue interface signal

The control signal between each device or unit of the NC system can use analogue interface signals. Analogue input and output interface signals should be in accordance with the provisions of IEC 61131-2:2007, 5.3.

5.2.2 Digital interface signal

Digital pulse interface signals between each device or unit for NC systems can have many types: control level signal, interface signal, feed pulse interface signal, measurement feedback interface signal, communication interface signal (e.g. RS232/485, USB, keyboard interface). The NC system

manufacturers should specify them in the product specification or the manual. For pulse interface signals and level interface signals, their types, pulse rate, signal level and signal current should be further specified.

5.2.3 Fieldbus interface

The NC system manufacturer should explain the fieldbuses used in the product instructions or manual.

The fieldbus interface should be designed and implemented in accordance with relevant parts of IEC 61158 and IEC 61784-3.

5.3 Environmental requirements of NC systems

5.3.1 General

Electrical equipment shall be suitable for the physical environment and operating conditions of its intended use. When special conditions apply or the limits specified are exceeded, an exchange of information between user and supplier is necessary.

NOTE Environmental requirements for NC systems can be found in IEC 60204-1, IEC 61800-1, IEC 61800-2 and IEC 61131-2.

5.3.2 Temperature, humidity and atmospheric pressure environmental adaptability requirements

NC systems shall be able to be operated, stored and transported in conditions in accordance with IEC 60204-1.

5.3.3 Mechanical environment adaptability

NC systems shall be able to withstand shock (impact) and vibration under the conditions given in Table 1, according to IEC 60068-2-6 and IEC 60068-2-27.

Table 1 — Vibration and shock test requirements for NC systems

Vibration (sinusoidal) test (NC system is running)		Shock test (NC system is not running)	
Frequency range	10 Hz to 55 Hz	Impact acceleration	300 m/s^2
Sweep rate	1 octave/min.	Shock wave	half-sine wave
Amplitude peak	0,15 mm	Time of duration	18 ms
Direction of vibration	xyz	Direction	Perpendicular to the bottom surface
Sweep cycle number	10 one times / axis	Shock number	3

NC systems shall be provided by the supplier with a standard packing box for transport, and shall be able to withstand provisions of the Table 2, transportation impact test.

Table 2 — Requirements for transport shock limit test

Mass (packaging included) kg	Free-fall height m
Mass < 20	0,25
20 < Mass < 100	0,25
100 ≤ Mass	0,10

5.4 EMC immunity requirements of NC systems

5.4.1 EMC basic requirements for NC systems

NC systems shall not generate electromagnetic disturbances above levels that are appropriate for its intended operating environment. In addition, the NC system shall have a sufficient level of EMC immunity to electromagnetic disturbances to function in its intended environment.

NOTE 1 The general EMC emission and immunity limits are given in IEC 61000-6-1 or IEC 61000-6-2 and IEC 61000-6-3 or IEC 61000-6-4.

NOTE 2 EMC requirements for NC machine tools are given in IEC TS 60204-34.

5.4.2 Criteria of EMC immunity

The acceptance criteria related to immunity tests (performance criterion) are given in IEC 61000-6-2 or IEC 61800-3.

5.4.3 EMC basic immunity performance requirements for NC systems

EMC immunity requirements for NC systems should be in accordance with IEC 61000-6-2 and IEC 61800-3.

Basic EMC immunity requirements for NC systems under second environment include electrostatic discharge (ESD) immunity, burst immunity, surge immunity and power supply voltage dip/ interruption immunity.

Radio frequency (RF) electromagnetic field radiation immunity and RF field induced conduction immunity are necessary.

EMC immunity test requirements for NC systems are listed in Tables 3 to 5. See 6.5 for the test method.

Table 3 — NC system immunity requirements under second environment (enclosure ports)

Ports	Phenomenon	Reference document	Performance (acceptance) criterion
Enclosure ports	Contact discharge or air discharge	IEC 61000-4-2:2008	A
	Radio frequency (RF) electromagnetic field radiated[a]	IEC 61000-4-3:2020	B
	Power frequency magnetic field[b]	IEC 61000-4-8:2009	B

[a] General NC systems are applicable.

[b] Applies to NC system with CRT display or to electromagnetic sensitive components.

Table 4 — NC system EMC immunity requirements under second environment (power ports)

Ports	Phenomenon	Reference document	Performance (acceptance) criterion
The AC power port (AC input power line, protection earth wire)	Burst (The use of power coupling network)	IEC 61000-4-4:2012	B
	Surge[a]: the waveform parameters are 1,2 / 50 µs 8 / 20 µs	IEC 61000-4-5:2014	B
	Radio frequency (RF) fields induced conducted disturbances[b]	IEC 61000-4-6:2013	A
	Voltage short interruption	IEC 61000-4-11:2020	A
			A
	Voltage dip	IEC 61000-4-11:2020	C
The motor power port (motor DC of driving device, protection earth wire)	Burst (use capacitive coupling clamp) [b, c]	IEC 61000–4-4:2012	B
DC power port (DC input power line, protection earth wire)	Burst (use power coupling network)[c]	IEC 61000-4-4:2012	B

[a] Use only light load test conditions of the working current less than 63A.

[b] Applicable only to ports or interfaces with cables whose total length according to the instructions or manual may exceed 3 m.

[c] Applicable to the general NC system.

Table 5 — NC system immunity requirements under second environment (computer signal ports)

Ports	Phenomenon	Reference document	Performance (acceptance) criterion
Field bus or other due to technical reasons not suitable to use the signal interface of surge protection device is not required.	Burst (The use of capacitive coupling clamp)	IEC 61000-4-4:2012	B
	Surge [b, c] 1,2 / 50 µs 8 / 20 µs	IEC 61000-4-5:2014	B
	Radio frequency (RF) fields Induced conducted disturbances [a c]	IEC 61000-4-6:2013	A
Computer signal port / interface (RS232/485, USB, keyboard line, Fieldbus signal wire)	Burst (use capacitive coupling clamp)[a]	IEC 61000–4-4:2012	B

[a] Applicable only to ports or interfaces with cables whose total length according to the instructions or manual may exceed 3 m.

[b] Applicable only to ports or interfaces with cables whose total length according to the instructions or manual may exceed 30 m. In the case of a shielded cable, a direct coupling to the shield is applied. This immunity requirement does not apply to fieldbus or other signal interfaces where the use of surge protection devices is not practical for technical reasons. The test is not required where normal functioning cannot be achieved because of the impact of the coupling/decoupling network on the NC systems.

[c] Applicable to the general NC system.

5.5 Protection and safety requirements of NC systems

NC systems which provide functional safety should provide such functions in accordance with ISO 13849-1 and IEC 61800-5-2 where applicable.

NC systems shall provide access control, e.g. by key switches or passwords, to prevent unintentional changes to NC-programs/process programs. Any changes to software or parameters related to safety require authorization.

5.6 Document requirements for NC system

5.6.1 Technical documentation

The manufacturer of the NC system shall provide the user with an accompanying instruction or user manual. Contents should include at least product specifications, installation, connection, operation, and programming.

All of these technical documents shall meet the requirements of IEC 82079-1.

NOTE 1 The instructions are written in the language of the country where the equipment is used.

NOTE 2 In some countries, the use of specific language(s) can be required.

5.6.2 Guarantee file

The manufacturer of the NC system should provide a certificate of product qualification and warranty documents.

5.6.3 Packaging documentation

The manufacturer of the NC system shall provide the user with a packing list including:

— quantity of packing boxes, model of product, name and quantity,

— name, model and quantity of accompanying accessories, if any,

— name and quantity of the accompanying technical documents.

5.6.4 Nameplate

The NC system nameplate shall include the following information and should be legibly and durably marked in a way that is visible after the equipment is installed on enclosures that receive incoming power supplies:

— type designation or model,

— name or trademark of supplier,

— rated voltage, number of phases and frequency (if AC), and rated current, rated power,

— certification mark or other marking, when required,

— serial number where applicable.

It is recommended that the NC system nameplate is provided adjacent to the main incoming power supply.

6 Test method

6.1 Test conditions of NC systems

Except for special test items for special requirements of the NC system, tests shall be in accordance with Table 6. For the test to determine accuracy of basic properties and technical parameters and reference test, the atmospheric conditions shall be in accordance with Table 7.

Table 6 — Atmospheric conditions for general testing

Item	Test conditions
Ambient temperature	15 °C to 35 °C
Relative humidity	25 % to 75 %
Atmospheric pressure	92 kPa to 106 kPa (Altitude lower than 1 000 m)
NOTE The electromagnetic conditions in the EMC laboratory do not adversely affect the test results.	

Table 7 — Atmospheric conditions for reference test

Item	Test conditions
Nominal temperature	23 °C ± 1 °C
Relative humidity	48 % to 52 %
Atmospheric pressure	92 kPa to 106 kPa (Altitude lower than 1 000 m)

6.2 Function test of NC systems

The functional test of the NC system shall be carried out according to the requirements of 5.1. Different products should be tested one by one according to their specific functional test items.

6.3 Inspection for basic design requirements of NC systems

For each device or unit of the NC system, a visual inspection method and other necessary methods shall be used to test basic design requirements, e.g. structure and appearance, marking, colour, protection, operability and maintainability, nameplate. All test items shall be in accordance with 5.3.

6.4 Environmental test of NC systems

6.4.1 Temperature and humidity adaptability test

6.4.1.1 General

General requirements of temperature and humidity suitability tests include:

— At the beginning of the test, the NC system shall not be packaged unless there are other special requirements in the standard. The system shall be normally connected and shall be attached with an attachment for normal operation. The system should be in a ready-to-use condition.

— For a run test with power supply, the voltage of the power supply shall be within ±10 % of the rated value.

— The temperature and humidity adaptability test of the NC system can be carried out under no-load conditions, and the motor(s) of the NC system can be placed outside the temperature-controlled chamber.

— Before and after each test, a visual inspection and functional test of the NC system shall be carried out to determine the impact of the test on the system and to determine whether the NCSUT has been passed or not.

6.4.1.2 Low temperature operation test

Test method: According to the test Ad of IEC 60068-2-1:2007.

6.4.1.3 High temperature operation test

Test method: According to test Bd of IEC 60068-2-2:2007.

6.4.1.4 Operating temperature change test

Test method: According to test Nb of IEC 60068-2-14:2009.

6.4.1.5 Storage and transportation low temperature test

Test method: According to test Ab of IEC 60068-2-1:2007.

6.4.1.6 Steady-state damp heat test

Test method: According to test Cab of IEC 60068-2-78:2012.

6.4.2 Mechanical environmental adaptability test

6.4.2.1 Vibration test

Test method: According to test Fc of IEC 60068-2-6:2007.

6.4.2.2 Shock (impact) test

Test method: According to test Ea of IEC 60068-2-27:2008.

6.4.2.3 Free fall test

Test objective: Adaptability of packaged NC system to impact during transportation.

Test method: According to test Ec of IEC 60068-2-31:2008 (E).

Test conditions:

— mass < 100 kg (with package): height of free fall 0,25 m,

— mass ≥ 100 kg (with package): height of free fall 0,1 m,

— times of free fall: 2 times, fall test only for bottom of the package.

Test surface: smooth, hard, rigid surface of concrete or steel.

Test procedure:

a) Before test, the appearance of the NC system with package shall be without damage and function normally.

NOTE Drop height refers to the distance between the test surface and the nearest sample before test.

b) Test sample shall be free fall from the suspended position. Minimize interference when released.

c) Structure and appearance of the NC system shall be inspected after the test, and no mechanical damage, deformation, parts shedding or loosening. Finally, the functional test of the NC system shall be normal.

6.4.3 Power environment adaptability test

Test objective: adaptability of the NC system to voltage and frequency fluctuation of AC input power supply.

Test equipment: variable frequency power supply, of which the output voltage and output frequency adjustable, and the capacity of the power supply shall be greater than that of the NCSUT.

Test method: Take the NC system voltage deviation test in running state. The NC system runs with no-load during test. The NC system shall run normally during the test. The test condition shall consider voltage level and frequency of different country or regions.

Test time: duration of the test is at least 15 min under each combination condition. During each period, the check procedure shall be performed at least once.

Table 8 — Test conditions of power environment adaptability

Power supply voltage 220 V AC		Power supply voltage 380 V AC	
Voltage	Frequency	Voltage	Frequency
V	Hz	V	Hz
187	49	323	49
	51		51
242	49	418	49
	51		51
NOTE Table 8 is an example of test conditions widely used in China.			

6.5 EMC immunity test of NC systems

6.5.1 Electrostatic discharge (ESD) immunity test

Test objective: EMC immunity performance of the NC system.

Test method: According to IEC 61000-4-2:2008.

Test voltage: Contact discharge ±4 kV, Air discharge ±8 kV.

Relative humidity of the laboratory: 30 % to 60 %.

In order to minimize the impact of environmental parameters on test results, the tests and calibration shall be carried out in climatic and electromagnetic reference conditions as specified in IEC 61000-4-2:2008, 8.1.2 and 8.1.3.

Acceptance (performance) criterion: B.

Test equipment: ESD generator. Characteristics and performance of the ESD generator shall be in accordance with IEC 61000-4-2:2008.

Test implementation:

a) After initial inspection, the NC system is placed on the test platform and is energized and operated normally under no-load conditions. A desktop system is placed on a wooden bracket 800 mm above the ground reference plane, and cabinet type (landing) system is placed on a wooden bracket from 100 mm above the ground reference plane.

b) Position of ESD: cabinet, enclosure and operation panel, keyboard, buttons, switches, connectors, locations where hands can touch it.

c) For a connector shell with a metal part, contact discharge should be used and acted on the metal part of the shell. For a connector shell with insulating material, air discharge should be used and acted on the shell of insulation. Neither discharge shall be applied to the contact of the connector.

d) Preferred contact discharge, non-insulating paint shall not be used for insulating materials. If the surface is covered by insulation, air discharge shall be adopted.

e) Discharge at a frequency of 20 times per second to find sensitive points for telectrostatic discharge. Apply single discharge at each sensitive point, with each polarity discharged at least 10 times with an interval no less than 1 s.

f) The test shall conform to the B acceptance (performance) criteria, as specified in IEC 61800-3:2017.

6.5.2 Electrical fast transient/burst immunity test

Test objective: electrical fast transient/burst immunity performance of the NC system.

Test method: According to IEC 61000-4-4:2012.

Test voltage/frequency:

— power supply port/interface (AC/DC power line, protection, grounding wire, motor power wire): 2 kV/5 kHz,

— signal interfaces of control and measurement (level, pulse, analogue etc. signal wire): 2 kV/5 kHz,

— Computer signal port/interface (RS232/485, USB, keyboard line, fieldbus): 1 kV/5 kHz.

NOTE Only when the length of DC power line, motor power line and various signal lines are more than 3 m, is the test is needed (according to the product manual).

Acceptance (performance) criterion: B.

Test equipment: Fast transient/burst generator and capacitive coupling clamp in accordance with IEC 61000-4-4:2012, Clause 6.

Test implementation:

a) The minimum distance between NCSUT and other conductive objects (e.g. a conductive wall in Shielding room), shall be greater than 0,5 m the minimum distance between capacitive coupling clip and other conductive objects (e.g. a conductive wall in Shielding room), and shall be greater than 0,5 m (except for the ground reference plane). The distance between the grounding cable, other cables and grounding reference plane shall be kept at 100 mm.

b) Various power lines and various signal lines shall be tested separately for each device and unit of the NC system.

c) For single-phase or three-phase power supply, every line including the PE line shall be interfered separately. In addition, L, N and PE lines shall be interfered simultaneously for single-phase power supply.

d) For AC power lines, DC power lines and protective ground lines: use a power supply coupled network, and a power line length of no more than 1 m. If the power line is more than 1 m and cannot be removed, it shall be bent into a flat loop of 400 mm in diameter and be placed in parallel with the reference ground plane at a height of 100 mm.

e) For the measure / control signal line, the computer signal line: use the capacitive coupling clip. Pay attention to adjust the length of the signal line between the coupling clip and NC device in accordance with IEC 61000-4-4:2012.

f) For the motor power line, use the capacitive coupling clip, and pulse burst coupled to motor each power line without shielding layer.

g) Each test shall be separately applied to disturbance of positive/negative polarity, and the duration of each disturbance shall be at least 1 min.

h) The test shall conform to the B acceptance (performance) criteria, as specified in IEC 61000-6-2 or IEC 61800-3.

6.5.3 Surge immunity test

Test objective: Surge immunity performance of the NC system.

Test method: According to IEC 61000-4-5:2014.

Test voltage:

— power port (AC power line, protective earth line PE): 1 kV (line-to-line coupling), 2 kV (line-to-earth coupling).

— signal interfaces of control and measurement (level, pulse, analogue signal line): 1 kV (line-to-earth coupling).

NOTE 1 This test is only required when the total length of the signal line may exceed 30 m (according to the product manual).

NOTE 2 If the signal line uses a shielded cable, it is directly coupled to the shielding layer. For field bus or other signal interfaces that are not suitable for the surge protection device due to technical reasons, the requirement is not made. For the influence of coupling/decoupling network that leads to the failure of normal functions of NC system, this test is not required.

Acceptance (performance) criterion: B.

Test equipment: combination wave generators in accordance with IEC 61000-4-5:2014, Clause 6.

Test implementation:

a) Power lines for AC power ports: Surge shall be applied at 0°, 90°, and 270° phase angles of voltage waveform. Test voltage: line-to-line is 1 kV. Line-to-PE is 2 kV, line-to-neutral is 2 kV. External surge protection device and external power filter shall not be added during the test (unless there are special protection requirements for the NCUT). Connection length between the power coupling network and the NCUT shall not exceed 2 m.

b) Test voltage level is applied with positive/negative polarity 5 times each at an interval at least 1 min apart.

NOTE The preferred range of test levels is given in IEC 61000-4-5:2014, Table 1.

c) The test shall be carried out from low to high according to voltage level. For example, for test requirements of 2 kV, the test shall be performed step-by-step in the order of 500 V, 1 kV and 2 kV. Each level of test voltage shall be applied with positive/negative polarity 5 times, and each voltage level test shall meet the requirements of B-level acceptance (performance) criteria.

d) The test shall conform to B acceptance (performance) criteria, as specified in IEC 61800-3:2017.

e) Due to the danger of the surge test, operators shall follow the safety instructions for instrument operation. At the same time, as the surge test can damage the NC system, it shall be placed last in each test.

6.5.4 Voltage dip and short interruption immunity test

Test objective: Voltage dip and short interruption immunity performance of the NC system.

Test method: According to IEC 61000-4-11:2020.

See Table 9 for test levels and acceptance (performance) criteria.

Table 9 — Voltage dip, short interruption test levels

Test level %UT	Voltag dips, short interruptions % UT	Duration ms	Acceptance (performance) criteria
0	100	3	A
40	60	200	C
70	30	500	A
NOTE UT is the rated AC power voltage of the NC system.			

Test equipment: voltage dip and short interruption generators whose output waveform shall conform to IEC 61000-4-11:2020.

Test implementation:

a) The test shall be applied to all the external AC power input ports. Rated voltage UT shall be the rated AC power voltage of the NC system.

b) The voltage dip and short interruption immunity tests shall be made at the rated output load of the NC system. If this is not possible, load status shall be given in the test report (e.g. servo motor no-load).

c) The length of power line of the NC system shall be the shortest line length that is suitable for the NCUT.

d) During testing, the power supply voltage shall be monitored to be within 2 % accuracy, and zero-crossing control of the generator shall be within 10 % accuracy.

e) The initial test voltage in the voltage dip and short interruption immunity test shall be the nominal value of UT, the output voltage error of the generator shall be within ±5 %, and its voltage output variation with the load shall conform to IEC 61000-4-11:2020, Clause 6.

f) Test level 0 % UT is equivalent to voltage short interruption. The initial phase angle shall be 0°, 90°, and 270° in the test. For three-phase power supply systems, the initial phase angle of one phase is used as a benchmark, and phase by phase the separate voltage interrupt tests are conducted, followed by the three-phase voltage interrupt test. Each test shall be done at least three times at intervals of at least 10 s.

g) Test level 40 % UT and 70 % UT are the voltage dip test. The initial phase angle is arbitrary. Either test level can be chosen. For three-phase power supply systems, voltage dip tests are conducted phase by phase separately. Each test shall be done at least three times at intervals of at least 10 s.

h) According to acceptance (performance) criteria C, after the NCUT has been turned off, or system protection and failure, the NCUT can be rebooted according to the scheduled start-up procedure under manual operation. See the rules in IEC 61800-3:2017.

6.5.5 Radio-frequency radiated immunity test

Test objective: radio-frequency radiated immunity performance of the NC system.

Test method: According to IEC 61000-4-3:2020.

Test parameters: frequency range of 80 MHz to 1 000 MHz, field strength 10 V/m, signal amplitude modulation 80 %, amplitude modulation AM (1 kHz).

Acceptance (performance) criteria: A, see IEC 61800-3:2017.

Test equipment: equipment in accordance with IEC 61000-4-3:2020 and test in an anechoic chamber.

Test implementation: test action to closed electric cabinet / enclosures of the NC system or device.

6.5.6 Radio-frequency field conduction immunity test

Test objective: radio-frequency field conduction immunity performance of the NC system.

Test method: According to IEC 61000-4-6:2013.

Test parameters: frequency range of 0,15 MHz to 80 MHz, radio-frequency voltage 10 V, signal amplitude modulation 80 % amplitude modulation AM (1 kHz).

NOTE This test is carried out only when the total length of the power supply line or signal line may exceed 3 m (according to the product manual).

Acceptance (performance) criteria: A, see IEC 61800-3:2017.

Test equipment: equipment in accordance with IEC 61000-4-6:2013.

Test implementation:

a) Test action on power line of AC power port, signal line of the control and measurement interface.

b) Each device of the NC system shall be placed on the ground reference plane through 100 mm insulation blocks. The distance between test device and the conductive body (e.g. the conductive wall) is at least 0,5 m. In the test, one of the devices or units is used as under measuring device, and the other is the function device for making the NC system work normally. Then take turns to enable each device or unit to be tested.

c) The connection cable between each device or unit shall be higher than the reference plane for 30 mm to 50 mm. Cables less than or equal to 1 m shall be 100 mm above the reference plane.

d) Select direct coupling (power line) or coupling clamp coupling (control and measurement signal line) according to type of cable under test.

e) The frequency range of 150 kHz to 80 MHz is scanned using 10 V radio-frequency voltages. The disturbance signal was 80 % amplitude modulated by 1 kHz sine wave. When needed, the test can be suspended to adjust the radio-frequency signal level or operation coupling device. The scan speed shall be no more than $1{,}5 \times 10^{-3}$ decade/s. When the scan frequency increases, the scan step shall not exceed 1 % of the initial frequency, and thereafter no more than 1 % of the previous frequency value. The duration of each scan frequency shall be greater than the response time of device or unit under test.

f) Test shall conform to the A acceptance (performance) criteria, as specified in IEC 61800-3:2017.

6.5.7 Power frequency magnetic field immunity test

Test objective: Power frequency magnetic field immunity performance of the NC system.

Test method: According to IEC 61000-4-8:2009.

Test parameters: frequency 50 Hz, magnetic field intensity 30 A/m.

NOTE A test is only needed for the NC system or device with sensitive parts to electromagnetic field, e.g. NC system control device with a CRT.

When an NC system with a CRT display/monitor is tested, the magnetic intensity of the CRT shall be 3 A/m.

Acceptance (performance) criteria: A.