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

Part 2: Requirements for numerical control system integration

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Contents

Page

Foreword

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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) is the enabler to 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 system (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 electromagnetical interferences. Purchasers and operators of machine tools require confidence on the appropriate quality, durability and usability in order to ensure intended use and productivity.

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

Expected users of this document include:

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

— design engineers working for a machine tools 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.

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

Part 2: Requirements for numerical control system integration

1 Scope

This document specifies requirements for the integration of numerical control systems (NC systems). It consists of technical and inspection requirements and test methods.

This document is applicable to all machine tools using NC systems not already covered by class C standards (including metal cutting machine tools, metal forming machine tools and woodworking machine tools) and for 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.

NOTE NC system integration with machine tools is performed mainly by machine tool builders using an NC system to control their machine tools, system integrators by assembling machine tools with the NC system to a production line, and machine tool users by upgrading their existing equipment.

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

ISO 23218-1, *Industrial automation systems and integration — Physical device control — Numerical control systems for machine tools — Part 1: Requirements for numerical control systems*

IEC 60204-1:2016, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

IEC/TS 60204-34:2016, *Safety of machinery — Electrical equipment of machines — Part 34: Requirements for machine tools*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 61310-1, *Safety of machinery — Indication, marking and actuation — Part 1: Requirements for visual, acoustic and tactile signals*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2806, ISO 23218-1 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 using 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 a *numerical control system (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 NC system, and interface generally refers to the boundary of each unit in an NC system.

[SOURCE: IEC 60050-131:2002, 131-12-60, modified — The term "NC system" was added to the definition and in the Note 1 to entry, "An example of a port is a terminal pair" has been redrafted.]

3.3
surge
transient 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 — The term "voltage surge" has been modified to "surge" and "voltage wave" to "electrical current, voltage or power propagating".]

3.4
reliability
ability of a *numerical control system (NC system)* (3.1) to perform a required function under given conditions for a given time interval

Note 1 to entry: It is generally assumed that the NC system is in a state to perform this required function at the beginning of the time interval.

Note 2 to entry: Generally, NC system reliability performance is quantified using appropriate measures. In some applications, these measures include an expression of an NC system reliability performance as a probability, which is also called NC system reliability.

4 Symbols and abbreviated terms

AC	Alternating Current
DC	Direct Current
NC	Numerical control
SELV	Safe Extra-Low Voltage

5 Technical requirements

5.1 Basic requirements

5.1.1 Marking

The marks of NC systems shall be in accordance with IEC 60204-1:2016, 16.

5.1.2 Colour

5.1.2.1 Conductors

The conductor colours of NC systems shall be in accordance with IEC 60204-1:2016, 13.2.4.

5.1.2.2 Actuators

The colour of actuators shall be in accordance with IEC 60204-1:2016, 10.2 and IEC 61310-1.

5.1.2.3 Indicating elements

The indicating elements of NC systems shall be in accordance with IEC 60204-1:2016, 10.3.

5.1.3 Wires and connections

Wires and connections of NC systems shall be in accordance with IEC 60204-1:2016, 13.

5.1.4 Protection

5.1.4.1 Degrees of protection

Degrees of protection of cabinet and enclosure of NC systems shall be in accordance with IEC 60204-1:2016, 11.3.

5.1.4.2 Protection degree design

Protection degree design of cabinet and enclosure of NC systems shall be in accordance with IEC 60204-1:2016, 11.4.

5.1.4.3 Other requirements for protection

If work, storage and transportation environments have excessive pollutants, e.g. dust, acids, corrosive gases or salts, and radiation, IEC 61000-4-3 should be considered.

5.1.5 Operation and maintainability

Operation and maintainability of the cabinet and enclosures shall be in accordance with IEC 60204-1:2016, 11.2.

5.1.6 Nameplate

NC system enclosure nameplate shall include at least the following information:

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

— certification mark or other marking that can be required by local or regional legislation, when required, and

— serial number where applicable.

5.2 AC input power supply requirements

AC input power supply of NC system should consider the target market power supply system and earthing system should be in accordance to IEC 60364-1. According to the combination of neutral conductor N and protective conductor PE, there are three subsystems in the TN system:

— TN-S system: power systems TN with separate neutral function and the protective conductor throughout the system.

— TN-C systems: power systems TN with neutral and protective functions combined in a single conductor throughout the system.

— TN-C-S systems; power systems TN with neutral and protective functions combined in a single conductor in a part or throughout the system.

The TN-S power supply system should be used by an NC machine tool and NC system users.

NOTE In TN-S systems, its PE line and N line are completely separated. In normal work conditions, a PE line has no load current and the electromagnetic disturbance introduced is low. This is helpful to improve the stability and reliability of a complex NC system.

For NC machine tools and the NC system using a PE line connect to the earth separately (such as directly earthing through an independent electrode) and disconnecting with the power supply system, the power supply grounding system will change into a TT system. In this case, the NC system shall be equipped with a special isolation transformer, otherwise the protection circuit of an NC system will not be triggered when fault occurs, which can cause significant safety consequences on the system. The NC system manufacturer shall describe this in the product instructions or manual.

If a neutral conductor is used in the NC system, it shall be clearly described in technical documents (e.g. installation diagram and circuit diagram) and an N conductor with a special insulation terminal shall be provided. A PE conductor and N conductor in NC machine tools and NC systems are not allowed to connect in any case, and a PEN terminal shall not be used either.

When the NC system adopts the power supply of three-phase line of the AC 200 V to AC 220 V, the three-phase power transformer can be used. Three-phase power transformers can be used for isolation and suppression of power system electromagnetic disturbance. Parameters can be given in the instructions or manual by NC systems manufacturer.

5.3 Protection and safety requirements

5.3.1 Protection against electric shock

NC systems shall provide protection of persons against electric shock according to IEC 60204-1:2016, 6.

5.3.2 Safety protection of electric cabinet

Safety protection of electrical cabinets shall be in accordance with IEC/TS 60204-34:2016, 9.3.

5.3.3 Protective earth and protective bonding

Protective earth and protective bonding of NC systems shall be in accordance with IEC 60204-1:2016, 13.2.2.

5.3.4 Insulation resistance

For NC system in all kinds of working climate environments, the insulation resistance should be in accordance with IEC 60204-1, 18.3.

5.3.5 Withstand voltage

Withstand voltage should be in accordance with IEC 60204-1, 18.4.

6 Test methods

6.1 Electrical cabinet and enclosure protection degree test

The cabinet and enclosure of the NC system shall be in accordance with the protection degree required by 5.1.4. The test methods for the protection degree shall be in accordance with IEC 60529.

The protection degree of the operating panel of the build-in enclosure of the NC system shall be IP54.

6.2 Protection and safety test

6.2.1 Protection against electric shock test

Test objective: Test to ensure that operators or maintenance personnel are not injured by electric shock.

Test method: According to IEC 60204-1:2016.

Test procedure:

a) The electric cabinet and enclosure of the NC system shall be visually inspected according to the technical design requirements of products and shall meet the requirements of 5.3.1.

b) For cabinet and enclosure with protection degree requirements, the protective degree test shall be conducted in combination with 6.1 protection degree test.

c) For circuits with residual voltages, oscilloscopes or other instruments can be used to test their voltage waveform or numerical value when these circuits are turned off. If the residual voltage can not be guaranteed to drop below 60 V in 5 s, it shall be checked if there is a durability warning sign outside the enclosure.

Exempted from this requirement are components having a stored charge of 60 µC or less.

6.2.2 Safety verifycation of electric cabinet

Check the electrical cabinet of the NC system using visual inspection and make the safety check of the electrical cabinet door and power switch when power is switched on. The safety of the system should meet the requirements of 5.3.2.

6.2.3 Protective earthing and protective bonding circuit continuity test

Test objective: Inspect continuity and reliability of protective earthing and protective bonding circuit of the NC system.

Test method: According to IEC 60204-1:2016, 18.2.2.

Test procedure:

a) Visual inspection shall be conducted to check, e.g. the connection of the protective grounding port PE, colour of the protective conductor, marking, diameter of the wire, and the result shall meet the requirements of 5.3.3.

b) Resistance between the PE terminal and relevant points are part of the protective bonding circuit that shall be measured with a current between at least 0,2 A and approximately 10 A derived from an electrically separated supply source (e.g. SELV, see IEC 60364-4-41:2005, 414) having a maximum no-load voltage of 24 V AC or DC.

The resistance measured shall be in the expected range according to the length, the cross-sectional area and the material of the related protective conductors and protective bonding conductor(s).

6.2.4 Insulation resistance tests

Test objective: Verify insulation performance between the power input line of the NC system and the protection ground wire.

Test method: According to IEC 60204-1:2016,18.3.

Test equipment: accuracy is 1. 0 grade 500 V meter or equivalent other instruments.

Test procedure:

a) NC system shall disconnect the power supply, but the power switch of the NC system shall be switched on and contactor shall be connected.

b) Test voltage shall be appied between AC power supply input port and PE with megger for 1 min, and the measured insulation resistance shall be greater than 1 MΩ.

c) AC power input ports of every device and unit of the NC system shall be tested separately.

d) Test shall ensure that contact junction is reliable. Insulation resistance between test leads shall be large enough to make sure the result is correct.

e) If there is a surge protection device in the AC power input port of the NC system, which can activate during the test, or there are other devices not suitable for high voltage test, the device shall be temporarily disconnected.

f) Products under test shall be discharged after the test.

6.2.5 Withstand voltage tests

Test objective: Verify withstand voltage performance between power input line of the NC system and protective bonding circuit.

Test method: According to IEC 60204-1:2016, 18.4.

Test voltage: 1,000 VAC / 50 Hz, leakage current is not greater than 5 mA (AC).

NOTE 1 When the power supply voltage of the NC system does not exceed 50 V (AC) or 71 V (DC), test voltage is 500 V(DC), and leakage current is not greater than 10 mA (DC).

Test equipment: adjustable voltage source of 0 V to 3,000 V / 50 Hz and its capacity shall be not less than 500 VA, where special high-voltage test instruments can also be used. When the power supply voltage of the NC system does not exceed 50 V (AC) or 71 V (DC), a voltage source of 500 V (DC) can be used, where its capacity shall be not less than 500 VA.

Test procedure:

a) NC system shall disconnect the power supply, but the power switch of the NC system shall be switched on and the contactor in the NC device shall be connected.

b) NC system under test and test instruments shall be placed on the insulated workbench or insulating material plate (withstand voltage strength is over 3,000 V).

c) Test voltage shall start at a certain voltage below 500 V (AC) and gradually step up to 1 000 V (AC) and maintain 30 s, then gradually descend to zero. Rise and fall time shall be 5s to l0s, and leakage current shall not exceed 5 mA (AC). Breakdown or discharge shall not occur during the test.

NOTE 2 For a special high voltage tester, its rise and fall time is at least 1s.