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Metal Cutting Machines - General Specifications for Safeguarding

金属切削机床 安全防护通用技术规范

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Metal Cutting Machines - General Specifications for Safeguarding

1 Scope

This document specifies the basic safety protection technical requirements, measures and verification methods for the primary dangers associated with metal cutting machine tools.

This document applies to the design, manufacture and inspection of all metal cutting machine tools, their ancillary equipment and accessories.

NOTE: without causing any confusion, “metal-cutting machine tools” in this document is abbreviated as “machine tools”.

2 Normative References

The contents of the following documents constitute indispensable clauses of this document through the normative references in the text. In terms of references with a specified date, only versions with a specified date are applicable to this document. In terms of references without a specified date, the latest version (including all the modifications) is applicable to this document.

GB/T 191 Packaging - Pictorial Markings for Handling of Goods

GB/T 1251 (all parts) Ergonomics

GB/T 2893 (all parts) Graphical Symbols - Safety Colors and Safety Signs

GB/T 3167 Metal-cutting Machine Tools - Graphical Symbols for Operation Indications

GB/T 3168 Numerical Control of Machines - Symbols

GB/T 5226.1-2019 Electrical Safety of Machinery - Electrical Equipment of Machines - Part 1: General Requirements

GB/T 6576 Machine Tools - Lubrication Systems

GB/T 7247.1 Safety or Laser Products - Part 1: Equipment Classification and Requirements

GB/T 7247.4 Safety of Laser Products - Part 4: Laser Guards

GB/T 7247.5 Safety of Laser Products - Part 5: Manufacturer’s Checklist for GB/T 7247.1

GB/T 7247.14 Safety of Laser Products - Part 14: A User’s Guide

GB/T 7932-2017 Pneumatic Fluid Power - General Rules and Safety Requirements for Systems

GB/T 26118.1 Safety of Machinery - Assessment and Reduction of Risks Arising from Radiation Emitted by Machinery - Part 1: General Principles

GB/T 26118.2 Safety of Machinery - Assessment and Reduction of Risks Arising from Radiation Emitted by Machinery - Part 2: Radiation Emission Measurement Procedure

GB/T 26118.3 Safety of Machinery - Assessment and Reduction of Risks Arising from Radiation Emitted by Machinery - Part 3: Reduction of Radiation by Attenuation or Screening

GB/T 28780 Safety of Machinery - Integral Lighting System Used for Machines

GB/T 32812 Metal Working Fluid - Limit Requirements and Determination Methods of Hazardous Substances

GB/T 36954 Safety of Machinery - Implementation of Ergonomic Principles in Risk Assessment and Risk Reduction

GB/T 40806 Airborne Noise Emitted by Machine Tools - Operating Conditions for Metal-cutting Machines

JB/T 5062 Information Display Equipment - The General Require of Man-machine Engineering

JB/T 8356 Packaging of Machine Tool - Specifications

3 Terms and Definitions

The terms and definitions defined in GB/T 15706-2012 and the following are applicable to this document.

3.1 safety of machine tools

The condition, in which a machine tool performs its functions under the intended conditions of use (or within a given period) specified in the instruction manual and does not cause injury to personnel or harm to health or damage to equipment during transportation, installation, adjustment, maintenance, disassembly and handling.

NOTE: intended use refers to the reasonable use of the machine tool in accordance with the information provided by the manufacturer. Intended use must be consistent with the instructions in the instruction manual and take due account of foreseeable misuse.

3.2 harm

Physiological injury or harm to health.

[source: GB/T 15706-2012, 3.5]

3.3 machine tools danger

Safety guards other than guards.

NOTE: examples of protective devices are given in 3.28.1 ~ 3.28.9 of GB/T 15706-2012.

[source: GB/T 15706-2012, 3.28]

3.10 mode of Operation; MO

Under pre-defined protective measures, a collection that provides a certain number of machine tool functions.

NOTE: the mode of operation is not a function. The functions covered by that mode of operation are only available when the specific mode of operation is activated.

[source: ISO 16090-1:2022, 3.4]

3.11 remote service

A mode of service that transmits data with machine tools in different territories (regions) to provide troubleshooting, diagnosis, maintenance, data analysis or optimization.

NOTE: remote connections between the service provider and the machine tool can be established through various communication modes (such as telephone network, mobile wireless network, Ethernet).

3.12 information for use

Protective measures consisting of information media (such as texts, words, marks, signals, symbols, diagrams) that can be used alone or in combination to convey information to the user.

[source: GB/T 15706-2012, 3.22]

3.13 operator

A person who installs, uses, adjusts, maintains, cleans, repairs or transports machine tools.

4 Machine Tool Classification, Mode of Operation, and Configuration

4.1 Machine Tool Classification

In accordance with their application and associated dangers, machine tools can be classified into four categories, as shown in Table 1.

4.2 Mode of Operation of Machine Tools

Depending on the application, the mode of operation of machine tools can be categorized into five types (see Table 2) and must meet the following requirements:

a) The manual selection of the settings of the mode of operation of machine tools must be performed only by authorized personnel;

b) The number of authorized personnel must be limited to prevent accidental start-up or misuse of the mode selection device;

c) The selected mode of operation must be activated using an activation mode.

4.3 Configuration of Machine Tool Category and Mode of Operation

4.3.1 The configuration of machine tool category and mode of operation shall be in accordance with the provisions of Table 3.

4.3.2 Machine tools with multiple modes of operation (MO) (Category-2, Category-3 and Category-4) shall be equipped with an MO selection control device and shall comply with the provisions of 6.4.7.

5 Machine Tools Danger

5.1 Machine Tool Risk Assessment

A risk assessment of the machine tools, including danger identification and risk analysis, shall be conducted in accordance with the relevant stipulations of Chapter 4 and Chapter 5 of GB/T 15706-2012, GB/T 16856 and GB/T 36954, to estimate and evaluate the risks of the machine tools.

5.2 Identification of Machine Tools Dangers

When identifying machine tools danger, the dangers that may arise under various conditions during the machine tool's life cycle (commissioning, operation, adjustment, cleaning, repair and maintenance) shall be combined, including (but not limited to):

---Accidental start-up,

---Failure of the control system,

---Dangers arising from operators and other personnel entering dangerous areas,

---Reasonably foreseeable misuse by operators and other personnel (see 3.23 and 3.24 of GB/T 15706-2012),

---Other significant dangers associated with the machine tool.

5.3 Primary Dangers of Machine Tools

Table 4 lists the primary dangers of machine tools.

6 Safety Requirements and / or Safety Measures

6.1 General Requirements

6.1.1 Intrinsically safe design

All potential dangerous factors shall be eliminated or reduced to the greatest extent possible through intrinsically safe design measures. Safety protection or supplementary protective measures shall not be used to eliminate or reduce dangers.

6.1.2 Safety protection and / or supplementary protective measures

Where, due to the intended use and reasonably foreseeable misuse, intrinsically safe design measures cannot avoid or adequately limit dangers, necessary safeguards (guards and protective devices) and / or supplementary protective measures shall be implemented, including emergency stop devices, escape and rescue measures for trapped personnel, isolation and energy dissipation measures, measures for convenient and safe handling of heavy components, and safe access to the machine tool, etc.

6.1.3 Usage information

For residual risks that cannot be eliminated or reduced through intrinsically safe design measures and for which safeguards are ineffective or incompletely effective, operators shall be informed and warned through usage information. Usage information alone shall not replace the proper application of intrinsically safe design measures, safety protection and supplementary protective measures.

6.1.4 Safety requirements and / or risk reduction measures of machine tools

Machine tools shall comply with the safety requirements and / or risk reduction measures specified in this document. In addition, for other machine tool risks not considered in this document, measures specified in 6.1.1 ~ 6.1.3 shall also be implemented.

6.1.5 Basic safety requirements for each category of machine tools

6.1.5.1 Category-1 machine tools

Safety protection for Category-1 machine tools shall comply with the following provisions:

a) Guards shall be installed to prevent approaching cutting tools or rotating workpieces;

b) Continuous feed speed of the axis shall not exceed 2 m/min;

c) Fast moving speed using hold-and-run control shall not exceed 5 m/min (for small machine tools) or 10 m/min (for large machine tools);

d) During a stop or emergency stop, feed movement shall stop no later than the main movement.

6.1.5.2 Category-2 machine tools

Safety protection for Category-2 machine tools shall comply with the following provisions:

a) Fixed and / or movable guards shall be used in the working area. If the working area cannot be enclosed due to the size and geometrical shape of the workpieces, or other specific characteristics of the machine tools or their application, other combination modes (such as control room, perimeter fencing, or other protective devices) shall be implemented for safety protection;

b) When movable guards are open (if adjusted), machine tool movement shall comply with the following provisions:

   1) Axis feed movement shall be controlled by hold-and-run, with a speed not exceeding 2 m/min and a step size of less than 6 mm;

   2) The spindle rotation shall be controlled by hold-and-run, with a speed of the spindle (for grinders, the workpiece axis) not exceeding 50 r/min, or a “cycle start” command shall be executed after manual data input (MDI);

   3) For the start / stop command, without a tool, the spindle (for grinders, the workpiece axis) shall stop within 2 revolutions. In the event of a power outage or unexpected situation, the spindle shall cease to function by inertia;

NOTE: for machine tools using common AC motors, the spindle is allowed to cease to function by inertia.

4) During a stop or emergency stop, feed movement shall stop no later than the main movement.

6.1.5.3 Category-3 and Category-4 machine tools

When the guards of Category-3 and Category-4 machine tools are open, machine tool movement may only be performed if the requirements of 6.1.5.2 b) are met. Safety protection shall comply with the following provisions.

a) The working area shall be enclosed by fixed and / or interlocking movable guards. If the working area cannot be enclosed due to the size and geometrical shape of the workpieces, or other specific characteristics of the machine tools or their application, other combination modes (such as control room, perimeter fencing, or other protective devices) shall be implemented for safety protection;

NOTE: this excludes grinders.

b) Machine tools that may continue to operate for a period of time after power failure (e.g., sliding or rotating of the spindle) shall use guards with locking mechanisms to prevent access to the dangerous machine movement.

NOTE: this excludes grinders.

c) For machine tools where personnel's entire body approaches or remains within the dangerous areas, where it is not easily perceived by the operator, the following safety measures shall be implemented:

1) Use an inductive protective device.

2) Use technical means (e.g., a safety padlock) to prevent the door from closing.

3) Double confirmation (internal and external guards).

4) Confirmation from a position that allows viewing of the dangerous areas (direct start-up of the guard locking mechanism).

5) Provide protective devices (e.g., gravity, spring-operated, or padlock) to prevent the guard from closing or automatically closing.

d) Machine tools (e.g., a single set of Category-3 machine tool) with multiple working areas shall be equipped with safeguards (e.g., fixed or movable interlocked guards or protective devices) to prevent access to the dangerous working area. Limit devices (e.g., mechanical brakes, limit switches, or light curtains) shall be used to prevent unauthorized machine tool movement into adjacent working areas.

e) During a stop or emergency stop, feed movement shall stop no later than the main movement.

6.2 Machine Tool Structure

6.2.1 Stability

The structure and appearance layout of the machine tools shall ensure adequate stability. When the machine tools are in use (under the intended operating conditions specified in the instruction manual), there shall be no risk of accidental tipping, falling, or unintentional movement. If the structure and shape of the machine tools cannot ensure adequate stability, the instruction manual shall specify their anchoring measures, including anchor bolts, motion restrictions, acceleration / deceleration limits, load limits, and alarms when approaching stability limits and load limits. If anchor bolts are used, the machine tool manufacturer shall clearly specify the requirements for the bolts and foundation used.

6.2.2 Appearance

6.2.2.1 Accessible exposed parts shall be free of sharp edges, corners, rough surfaces, protrusions and openings that may cause personal injury. Sheet metal edges shall be free of burrs, hems or chamfers. Openings that could lead to entrapment shall be securely and reliably sealed or covered.

6.2.2.2 The layout of various pipelines of the machine tools shall be reasonable and unobstructed to prevent dangers like tripping.

6.2.2.3 Safety measures shall be implemented for protruding, moving and separating parts of the machine tools to prevent the dangers of bruises, bumps, scratches and scrapes.

6.2.3 Moving components

6.2.3.1 Moving components and transmission devices (such as chains, sprockets, gears, racks, pulleys, belts, worm gears, worms, shafts, guide rods, lead screws and chip conveyors, etc.) that may pose a risk of entanglement, inhalation, or entrainment shall be enclosed or equipped with safeguards or warning signs, unless their location is safe.

6.2.3.2 Between moving components or between moving components and stationary components, there shall be no dangers of squeezing and / or shearing. Otherwise, safety measures shall be implemented in accordance with the relevant provisions of GB/T 12265.

6.2.3.3 Reciprocating components of machine tools subject to inertial impact shall be equipped with reliable limit devices and, if necessary, reliable buffering measures. If installing limit devices is difficult, necessary safety measures shall be implemented.

6.2.3.4 Moving components that could be damaged by overload shall be equipped with overload safety devices. If this is not possible due to structural reasons, the machine tools' operating limits shall be indicated on the machine tools (or in the instruction manual).

6.2.3.5 Parts and components that could become loose during movement shall be equipped with anti-loosening measures (e.g., by installing an anti-loosening device).

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