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Machine tools — Safety — Stationary grinding machines

Machines-outils — Sécurité — Machines à meuler fixes

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Foreword

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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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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is Technical Committee ISO/TC 39, *Machine tools*, Subcommittee SC 10, *Safety*.

This first edition of ISO 16089 is an adaptation of European Standard EN 13218:2002+A1/AC:2010-04. Significant differences between the European Standard and ISO 16089 are as follows.

a) Introduction of a subdivision of grinding machines into three groups, based on the degree of automation. Specific safety measures for safe design for each group of grinding machines.

b) Introduction of the Mode of safe operation 3 (*optional special mode for manual intervention under restricted operating conditions)* with a separate selection device and specific safety measures, and a new informative Annex providing examples.

c) Instead of the categories of EN 954-1, the required performance level according to ISO 13849-1 is defined for relevant safety functions.

d) The decrease in the impact resistance of unprotected polycarbonate depending on the duration of use is shown in the form of an aging curve in Annex A.

e) Measures for the use of flammable metalworking fluids are given in the new Annex H.

f) Examples for the integration of extraction and fire extinguishing systems when using flammable metalworking fluids are given in the new Annex I.

g) Example for rotational speed limit monitoring of the wheel spindle given in the new Annex K.

Introduction

In order to take technological progress into account, it was decided to revise EN 13218 for this purpose. Due to the worldwide use of these machines, an agreement was made by CEN/TC 143 and ISO/TC 39/SC 10. According to the Vienna Agreement, this revision was carried out as ISO 16089.

A decisive aspect for the preparation of this standard was the consideration of foreseeable misuse, e.g. by means of manipulation of protective devices.

Safety measures for grinding machines are, in particular, characterized by guards with interlocking and guard locking, to effectively counteract risks of fracture of ceramic tools. In some special cases of grinding operations, guards can be regarded as disturbing by the operator because they obstruct process monitoring. Then, by means of manipulation of the interlocking devices, automatic mode without guard can occur with dramatically increased hazards for the operator. To reduce the incentive for manipulation, the possibility of using a special mode (MSO 3) was provided in the operating mode concept for grinding machines such as in the preceding standard EN 13218. This implies the same strong safety measures as for the operating mode setting. These restrictions offer a significant motivation for switching back into automatic mode where higher speeds and feed rates are available for a more profitable production. Comparisons of risks show that the provision of a special mode presents a much lower risk than a manipulated automatic mode.

At the time this International Standard was developed, it was already foreseen that the information given in A.3.2 on the wall thickness of abrasive product guards and in A.3.5 on the work zone enclosure will probably be modified by an Amendment to this International Standard, depending on the result of further scientific research.

Machine tools — Safety — Stationary grinding machines

1 Scope

This International Standard specifies the requirements and/or measures to eliminate the hazards or reduce the risks in the following groups of stationary grinding machines which are designed primarily to shape metal by grinding:

Group 1: Manually controlled grinding machines without power operated axes and without numerical control.

Group 2: Manually controlled grinding machines with power operated axes and limited numerically controlled capability, if applicable.

Group 3: Numerically controlled grinding machines.

NOTE 1 For detailed information on the groups of grinding machines, see the definitions in 3.1 and 3.4.

NOTE 2 Requirements in this International Standard are, in general, applicable to all groups of grinding machines. If requirements are applicable to some special group(s) of grinding machines only, then the special group(s) of grinding machine(s) is/are specified.

This International Standard covers the significant hazards listed in Clause 4 and applies to ancillary devices (e.g. for workpieces, tools, and workpiece holding devices, handling devices), which are integral to the machine.

This International Standard also applies to machines which are integrated into an automatic production line or grinding cell inasmuch as the hazards and risks arising are comparable to those of machines working separately.

This International Standard also includes in Clause 7 a minimum list of safety-relevant information which the manufacturer has to provide to the user. See also ISO 12100:2010, Figure 2, which illustrates the interaction of manufacturer's and user's responsibility for the operational safety.

The user's responsibility to identify specific hazards (e.g. fire and explosion) and reduce the associated risks can be critical (e.g. whether the central extraction system is working correctly).

Where additional metalworking processes (e.g. milling, turning, laser processing) are involved, this International Standard can be taken as a basis for safety requirements. For specific information on hazards arising from other metalworking processes, which are covered by other International Standards, see the Bibliography.

This International Standard applies to machines that are manufactured after the date of issue of this International Standard.

This International Standard does not apply to stationary honing, polishing, and belt grinding machines and not to transportable motor-operated electric tools in accordance with IEC 61029-2-4 and IEC 61029-2-10.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 447, *Machine tools — Direction of operation of controls*

ISO 2553, *Welding and allied processes — Symbolic representation on drawings — Welded joints*

ISO 3834-1, *Quality requirements for fusion welding of metallic materials — Part 1: Criteria for the selection of the appropriate level of quality requirements*

ISO 4413:2010, *Hydraulic fluid power — General rules and safety requirements for systems and their components*

ISO 4414:2010, *Pneumatic fluid power — General rules and safety requirements for systems and their components*

ISO 4871, *Acoustics — Declaration and verification of noise emission values of machinery and equipment*

ISO 5817, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections*

ISO 9355-1, *Ergonomic requirements for the design of displays and control actuators — Part 1: Human interactions with displays and control actuators*

ISO 9355-2, *Ergonomic requirements for the design of displays and control actuators — Part 2: Displays*

ISO 9355-3, *Ergonomic requirements for the design of displays and control actuators — Part 3: Control actuators*

ISO 9606-1, *Qualification testing of welders — Fusion welding — Part 1: Steels*

ISO 9606-2, *Qualification test of welders — Fusion welding — Part 2: Aluminium and aluminium alloys*

ISO 10218-1:2006, *Robots for industrial environments — Safety requirements — Part 1: Robots*

ISO 11161, *Safety of machinery — Integrated manufacturing systems — Basic requirements*

ISO 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 13849-1:2006, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 13850, *Safety of machinery — Emergency stop — Principles for design*

ISO 13856-2, *Safety of machinery — Pressure-sensitive protective devices — Part 2: General principles for design and testing of pressure-sensitive edges and pressure-sensitive bars*

ISO 13857:2008, *Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs*

ISO 14118:2000, *Safety of machinery — Prevention of unexpected start-up*

ISO 14119:1998, *Safety of machinery — Interlocking devices associated with guards — Principles for design and selection*

ISO 14120:2002, *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*

ISO 14122-1, *Safety of machinery — Permanent means of access to machinery — Part 1: Choice of fixed means of access between two levels*

ISO 14122-2, *Safety of machinery — Permanent means of access to machinery — Part 2: Working platforms and walkways*

ISO 14122-3, *Safety of machinery — Permanent means of access to machinery — Part 3: Stairs, stepladders and guard-rails*

ISO 14122-4, *Safety of machinery — Permanent means of access to machinery — Part 4: Fixed ladders*

ISO 15607, *Specification and qualification of welding procedures for metallic materials — General rules*

ISO 19719, *Machine tools — Work holding chucks — Vocabulary*

IEC 60204-1:2009, *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 61000-6-2, *Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity for industrial environments*

IEC 61000-6-4, *Electromagnetic compatibility (EMC) — Part 6-4: Generic standards — Emission standard for industrial environments*

IEC 61800-5-2, *Adjustable speed electrical power drive systems — Part 5-2: Safety requirements - Functional*

IEC 62061, *Safety of machinery — Functional safety of safety-related electrical, electronic and programmable electronic control systems*

EN 1127-1, *Explosive atmospheres — Explosion prevention and protection — Part 1: Basic concepts and methodology*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100, ISO 13849-1, and the following apply.

3.1 General terms

3.1.1
grinding machine
machine tool intended to machine workpieces by means of rotating grinding tools

Note 1 to entry: The machine can combine different types of grinding methods, e.g. external cylindrical grinding and internal cylindrical grinding.

3.1.1.1
stationary grinding machine
grinding machine (3.1.1) fixed in position during operation

Note 1 to entry: For types and groups of stationary grinding machines, see 3.4.

Note 2 to entry: In the following text of this International Standard, the term “grinding machines” will stand for “stationary grinding machines”.

3.1.2
manual control
control where each movement of the machine is individually initiated and controlled by the operator

3.1.3
manually controlled grinding machine
grinding machine (3.1.1) for which all process steps for the machining are controlled or started by an operator without support by an NC-machining program

3.1.4
numerical control
NC
automatic control of a process performed by a device that makes use of numeric data introduced while operation is in progress

[SOURCE: ISO 2806:1994, 2.1.1]

3.1.5
computerized numerical control
CNC
realization of *NC* (3.1.4) using a computer to control the machine functions

[SOURCE: ISO 2806:1994, 2.1.2]

3.1.6
numerically controlled grinding machine
NC grinding machine
grinding machine that operates under *numerical control* (3.1.4) or *computerized numerical control* (3.1.5)

3.1.7
power operated axis
axis which is operated by a force other than muscular or gravity force

3.1.8
abrasive product
grinding tool
rotary cutting tool of varied shapes with geometrically unspecified cutting edges made from abrasive grains and bond

Note 1 to entry: There is a distinction between bonded abrasive products and superabrasive products (see EN 12413 and EN 13236).

3.1.9
dressing tool
fixed or rotary tool for the generation or reproduction of the grinding capacity (sharpening) and/or the geometry (truing) of abrasive products

3.1.10
work zone
space where cutting is to take place

3.1.11
access to the hazard zone
entering or reaching the hazard zone either with individual parts of the body or with the whole body (whole body access)

3.1.12
operational stop
stop of the machine movements in the production process

Note 1 to entry: Control functions between control system and machine drives are maintained (torque, speed of rotation, position).

3.1.13
safe operational stop
operational stop with additional control system measures preventing dangerous machine movements due to control system faults

3.1.14
safe stop
stop by removal of the power to the machine actuators, preventing dangerous machine movements due to control system faults

3.1.15
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 13849-1:2006, 3.1.23, modified]

3.1.16
required performance level
PL_r
performance level (PL) applied in order to reach the required risk reduction for each safety function

[SOURCE: ISO 13489-1:2006, 3.1.24, modified]

3.2 Parts of grinding machines

3.2.1
vision panel
window provided in a guard through which the operator can view the *work zone* (3.1.10) or other areas of the machine

3.2.2
transparent screen
screen used on the machines for the protection of the face and the eyes of the operator from small pieces of debris and grinding sparks

3.2.3
chuck
clamping device in which workpieces are clamped either by manual force or with the aid of pneumatic, hydraulic, electric energy, or mechanically stored energy (e.g. preloaded springs)

Note 1 to entry: See Figure 1.

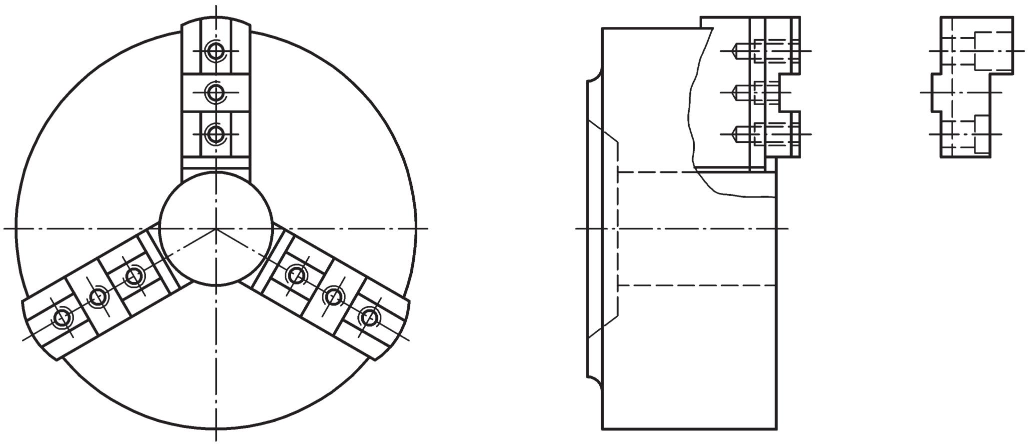


Figure 1 — Chuck

Note 2 to entry: The chuck with 3 jaws is only an example; a chuck can have 2, 3, 4, 6, etc. jaws.

[SOURCE: ISO 16156:2004, 3.1, 3.2, and 3.3, modified]

3.2.4
collet
chuck with multiple clamping
elements for the internal or external clamping of workpieces

[SOURCE: ISO 19719:2010, 1.5]

3.2.5
electronic handwheel
manually operated control device which initiates and maintains an axis movement by pulse generation input to the *numerical control* (3.1.4) during its rotation

3.2.6
abrasive product guard
guard which encloses the abrasive product exposing only the part necessary for grinding and which is designed and constructed in such a way that it retains fragments in the guarded area in the event of breakage of the abrasive product

3.2.7
work zone enclosure
guard for grinding machines, which is so designed that any ejected object (e.g. fragments abrasive product, part of machine, material, working fluid) are retained in the work zone (enclosed) and that access to the dangerous movement is prevented

3.2.8
tool holding device
device intended to secure and position the abrasive product on the wheel spindle

3.3 Modes of safe operation (MSO)

3.3.1
MSO 0
manual mode
mode with no automatic machine operation, where the operator has control over the machining process without the use of pre-programmed operations

Note 1 to entry: This can be controlled by the use of push buttons, mechanical or electronic hand wheels, or joysticks.

3.3.2
MSO 1
automatic mode
operation mode for the automatic, programmed, sequential operation of the machine, with the facility for manual or automatic loading/unloading of workpiece and tools, until stopped by program or operator

3.3.3
MSO 2
setting mode
operation mode in which adjustments for the subsequent machining process are performed by the operator

Note 1 to entry: Checking of grinding tool or workpiece position (e.g. by touching the workpiece with a probe or the grinding tool) are procedures of the setting mode. Adjustment includes machine setup operations.

3.3.4
MSO 3
optional special mode for manual intervention under restricted operating conditions mode
operation mode in which the possibility for manual intervention into the machining process, as well as for a limited automatic mode started by the operator, is given

EXAMPLE Programmed movements can be continued automatically, e.g by a program or the operator with movable guards open to access the work area.

3.3.5
MSO service
mode for service and maintenance tasks

Note 1 to entry: In MSO service, the machining of a workpiece is not allowed.

EXAMPLE Axis calibration by e.g. laser, ballbar testing, and/or spindle error analysis.

3.4 Types and groups of grinding machines defined in this International Standard

3.4.1 General

Grinding machines are subdivided into different groups with regard to the relevant hazards and into different types with regard to the grinding process. For examples for different types of grinding machines, see Table 1.

Table 1 — Types of grinding machines

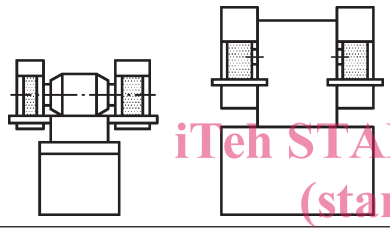
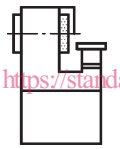
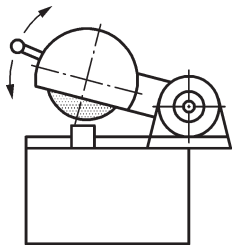
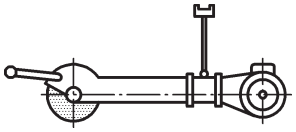
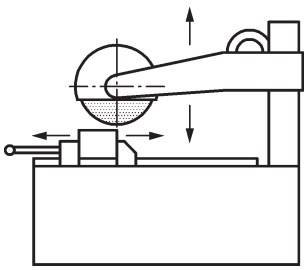
No.	Type of machine (scheme)	Designation	Grinding method
1.1		en: Bench or pedestal grinding machine fr: Touret pour établi ou sur socle de: Tisch- oder Ständerschleifmaschine	**Peripheral grinding** Grinding at the periphery of the abrasive products. The workpiece is guided by hand.
1.2		en: Pedestal grinding machine fr: Lapidaire de: Ständerschleifmaschine	**Side grinding** Grinding at the side of the abrasive products. The workpiece is guided by hand.
1.3		en: Cutting-off machine fr: Tronçonneuse de: Trennschleifmaschine	**Cutting-off** Grinding for the generation of cuts. The workpiece is fixed, the cutting-off wheel is mechanically guided (manual feed).
1.4		en: Swing frame grinding machine fr: Meulage et tronçonnage avec machine suspendue de: Pendelschleifmaschine	**Peripheral grinding, cutting-off** High pressure grinding at the periphery of the abrasive products. The workpiece is firmly attached or stabilized by its own weight. The grinding machine is suspended and guided by hand.
1.5		en: Cutting-off machine fr: Tronçonneuse de: Trennschleifmaschine	**Cutting-off** Grinding for the generation of slots or cuts. The workpiece is guided by hand. The cutting-off wheel is mechanically guided.

Table 1 *(continued)*

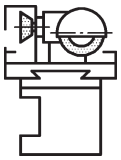
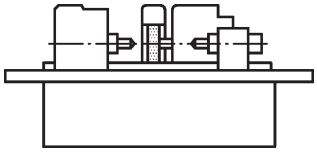
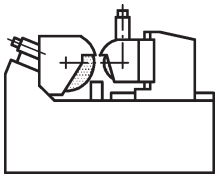
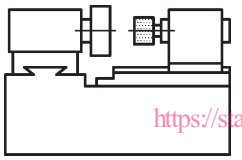
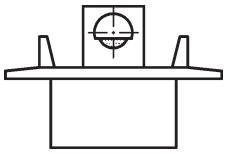
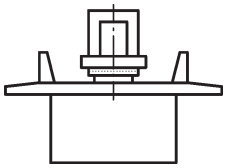
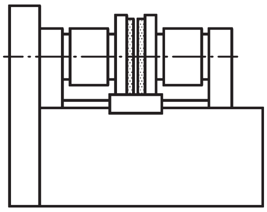
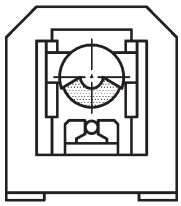
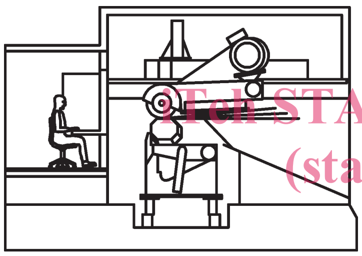
No.	Type of machine (scheme)	Designation	Grinding method
1.6		en: Tool grinding machine fr: Affûteuse de: Werkzeugschleif-maschine	**Peripheral and side grinding** Grinding for the generation or reproduction of cutting faces. Workpiece and abrasive product are mechanically guided.
1.7		en: External cylindrical grinding machine fr: Rectifieuse cylindrique extérieure de: Außenrundschleif-maschine	**External cylindrical grinding** Grinding for the generation of external surfaces at a rotating workpiece. Workpiece and abrasive product are mechanically guided
1.8		en: Centreless external cylindrical grinding machine fr: Rectifieuse cylindrique sans centre de: Spitzenlose Außenrund-schleifmaschine	**Centreless external cylindrical grinding** Grinding for the generation of external faces at a rotating workpiece. The workpiece is mechanically guided in its position to the abrasive product by a control wheel and rests on a guiderail between the two wheels
1.9		en: Internal cylindrical grinding machine fr: Rectifieuse cylindrique intérieure de: Innenrundschleif-maschine	**Internal cylindrical grinding** Grinding for the generation of internal faces at a rotating workpiece. Workpiece and abrasive product are mechanically guided.
1.10		en: Surface grinding machine, reciprocating or rotary table, horizontal spindle fr: Rectifieuse plane à table a déplacement rectiligne ou rotative– broche horizontale de: Planschleifmaschine, Rechteck- oder Rundtisch, waagerechte Spindel	**Surface grinding — Peripheral grinding** Grinding for the generation of plane surfaces, where the workpiece is attached to a table. Workpiece and abrasive product are mechanically guided.
1.11		en: Surface grinding machine, reciprocating or rotary table, vertical spindle fr: Rectifieuse plane à table a déplacement rectiligne ou rotative – broche verticale de: Planschleifmaschine, Rechteck- oder Rundtisch, senkrechte Spindel	**Surface grinding — Side grinding** Grinding for the generation of plane surfaces where the workpiece is attached to a table. Workpiece and abrasive product are mechanically guided.

Table 1 *(continued)*

No.	Type of machine (scheme)	Designation	Grinding method
1.12		en: Surface grinding machine, double spindle, horizontal or vertical fr: Rectifieuse plane à deux broches horizontales ou verticals de: Doppelspindel-Planschleifmaschine, waagerechte oder senkrechte Spindel	**Surface grinding — side grinding** Grinding of plane parallel opposite faces. Workpiece and abrasive product are mechanically guided.
1.13		en: Cutting-off machine fr: Tronçonneuse de: Trennschleifmaschine	**Cutting-off** Grinding for the generation of slots or cuts. Workpiece and abrasive product are mechanically guided.
1.14		en: High pressure grinding machine fr: Machine pour meulage à haute pression de: Hochdruckschleifmaschine	**Surface grinding** High pressure grinding for the generation of plane surfaces where the workpiece is attached to a table. Workpiece and abrasive product are mechanically guided.

3.4.2 Group 1: manually controlled grinding machine without power operated axes and without numerical control

Grinding machine without power operated axes with the exception of the wheel spindle and individual axes for rough positioning. All movements are initiated and controlled by the operator, one at a time.

This group of grinding machines can be equipped with the following features:

— mechanical facilities for mechanical feed;

— manual workpiece or tool guiding for processing;

— electronic facilities for constant surface speed (CSS);

— copying attachments (e.g. radius grinder, template);

— measuring equipment for workpiece outline (e.g. microscope);

— indexing equipment (partial device);

— power controlled rough positioning of individual axes.

Grinding machines of this group have no limited nor fully numeric control system (NC).

