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Machine tools — Safety — Stationary grinding machines

Machines-outils — Sécurité — Machines à meuler fixes

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International Organization for Standardization

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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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.

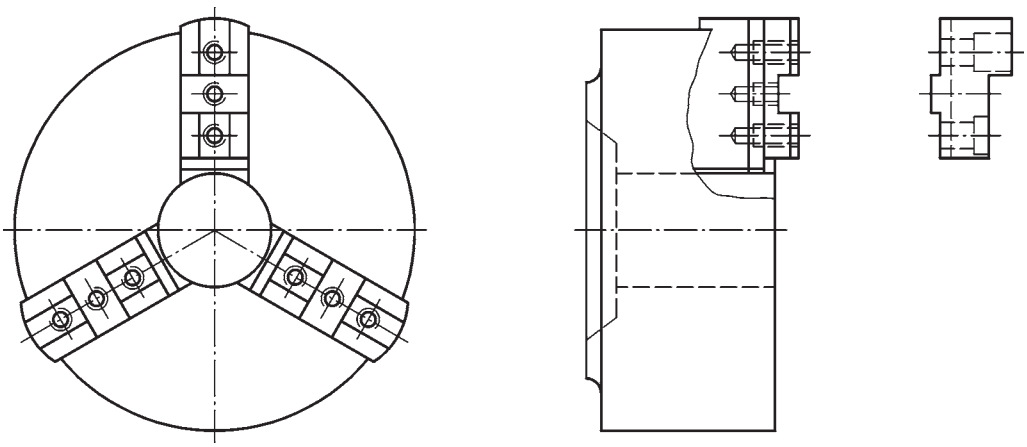


Figure 1 — Chuck

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

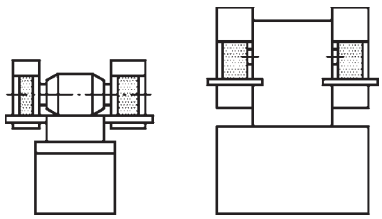
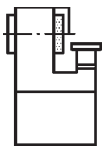
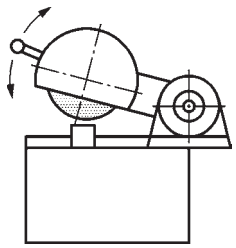
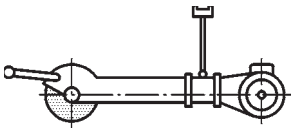
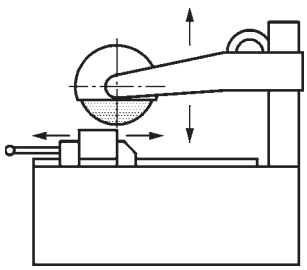
No.	Type of machine (scheme)	Designation	Grinding method
1.1		en: Bench or pedestal grinding machine fr: Touret pour établi ou sur socle de: Tisch- oder Ständerschleifmaschine	**Peripheral grinding** Grinding at the periphery of the abrasive products. The workpiece is guided by hand.
1.2		en: Pedestal 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)*

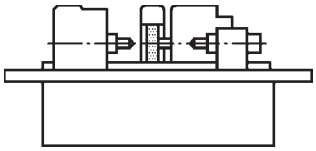
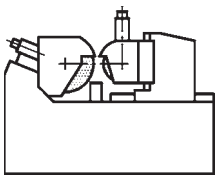
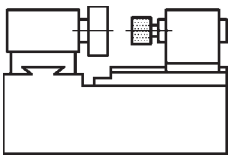
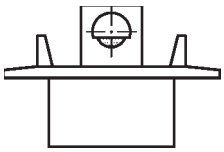
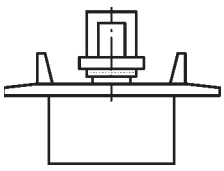
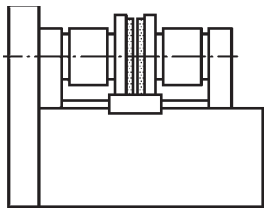
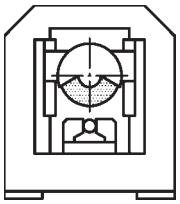
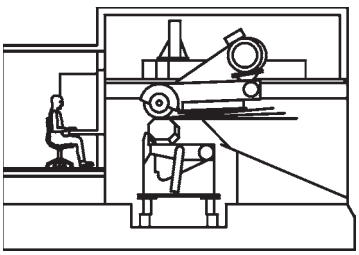
No.	Type of machine (scheme)	Designation	Grinding method
1.6		en: Tool grinding machine fr: Affûteuse de: Werkzeugschleifmaschine	**Peripheral and side grinding** Grinding for the generation or reproduction of cutting faces. Workpiece and abrasive product are mechanically guided.
1.7		en: External cylindrical grinding machine fr: Rectifieuse cylindrique extérieure de: Außenrundschleifmaschine	**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 Außenrundschleifmaschine	**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: Innenrundschleifmaschine	**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).

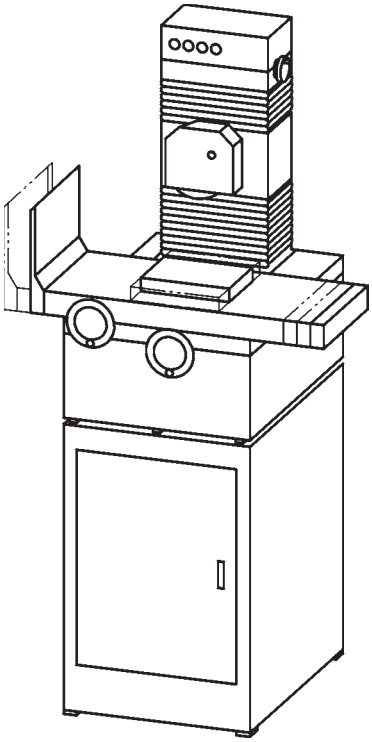


Figure 2 — Example of a group 1 grinding machine

3.4.3 Group 2: manually controlled grinding machine with power operated axes and, if applicable, with limited numerically controlled capability

Grinding machine with power operated axes that can be operated by the use of electronic handwheels or as a machine with limited NC control by operating controls on NC panel.

The feed movement between grinding tool and workpiece is carried out manually by physical force or power operated.

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

a) all of the features of group 1;

b) a limited numeric control system (NC) providing:

   1) MSO 0 exclusively;

   2) axis interpolation (i.e. copying/predefined profiling).

However, the following features are not provided:

— automatic program start;

— automatically initiated tool change system;

— automatic workpiece change system.

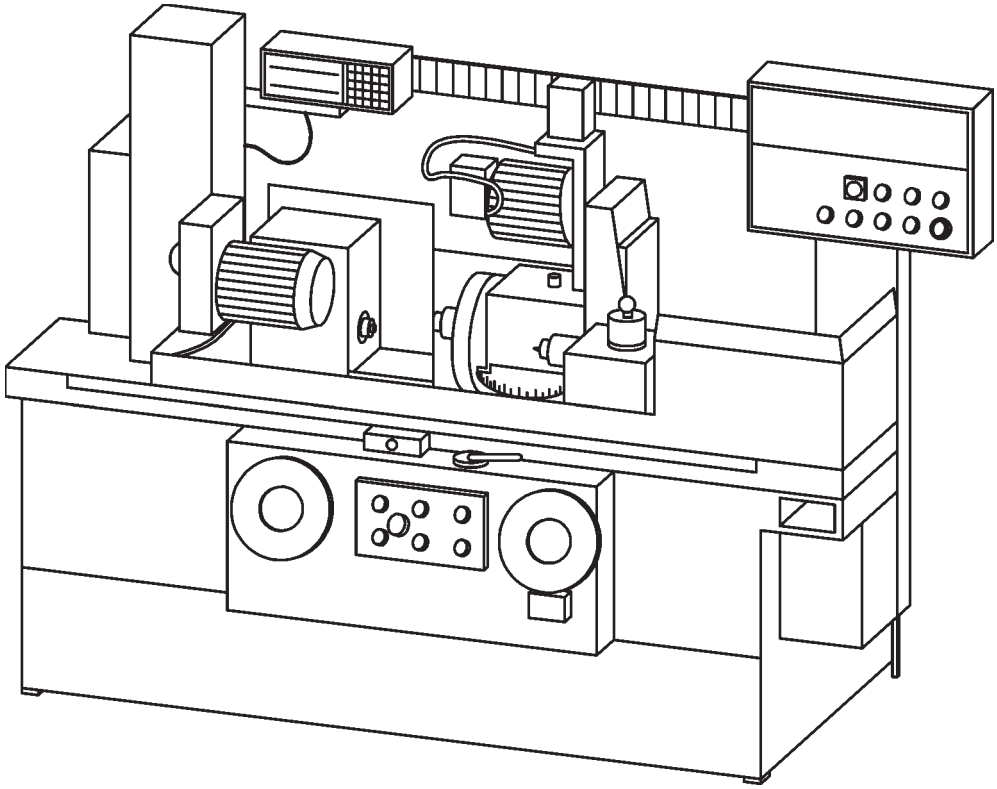


Figure 3 — Example of a group 2 grinding machine

3.4.4 Group 3: numerically controlled grinding machine

Grinding machine with numerical control (NC) providing automatic function.

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

a) a numeric control system with different modes of safe operation;

b) automatic workpiece change systems;

c) automatic tool magazine, tool transfer, and tool changing systems;

d) automatic tailstock quill advance or retreat;

e) automatic truing devices;

f) secondary machining operations (e.g. milling, turning, drilling);

g) additional ancillary handling devices.

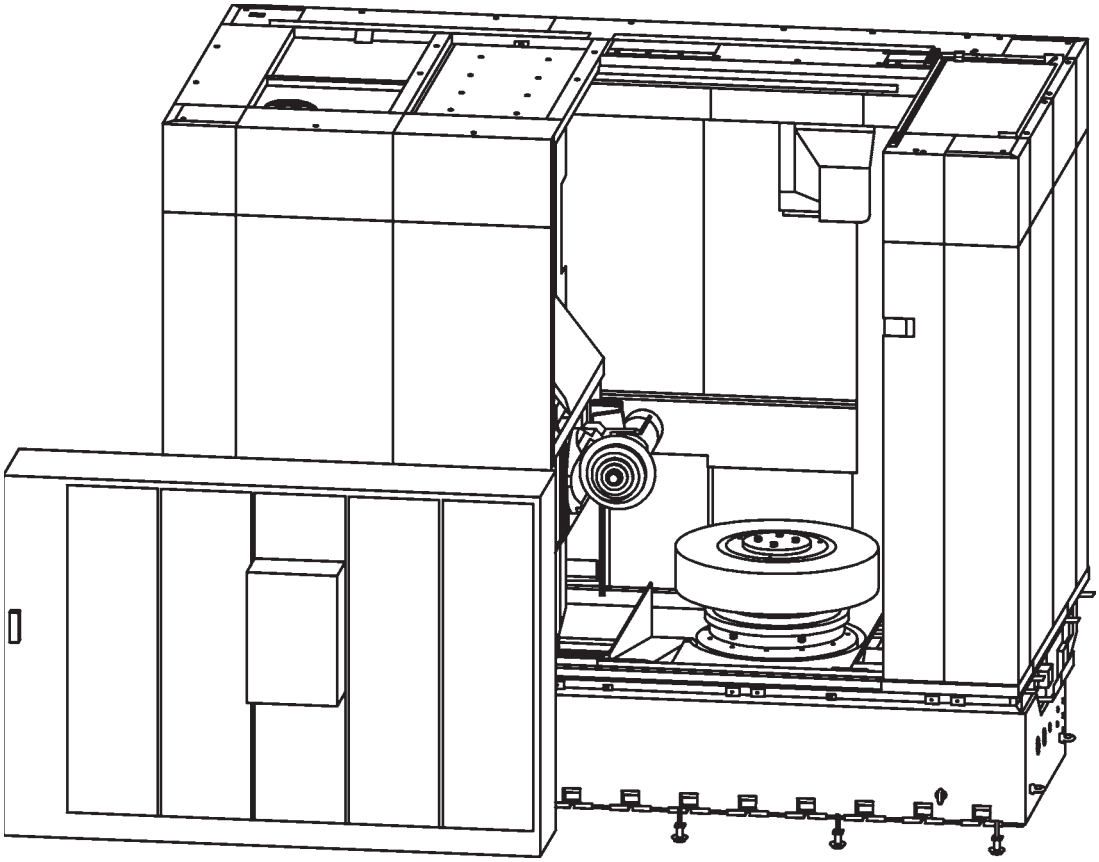


Figure 4 — Example 1 of a group 3 grinding machine

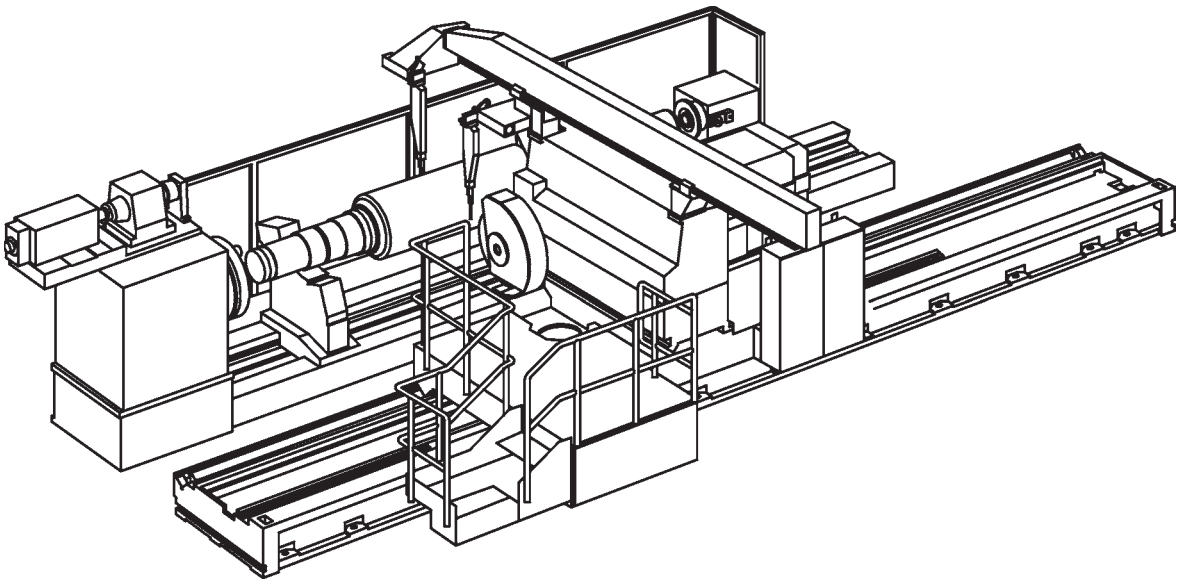


Figure 5 — Example 2 of a group 3 grinding machine

3.5 Speeds and axes speed

3.5.1
maximum operating speed
maximum permissible speed specified by the manufacturer of the abrasive product

3.5.2
maximum permissible speed
maximum permissible speed set as a machine parameter by the machine manufacturer

3.5.3
maximum possible speed
highest possible speed which occurs in case of failure

3.5.4
reduced speed
speed which is limited for safety related purposes by the machine manufacturer to a maximum permissible value

3.5.5
rotational speed
speed of an abrasive product calculated by the formula

$$n = \frac{v \times 1\,000 \times 60}{D \times \pi}$$

where

n is the rotational speed in rotations per minute;

v is the peripheral speed in metres per second;

D is the outside diameter of the abrasive product in millimetres.

3.5.6
peripheral speed
speed of an abrasive product calculated by the formula

$$v = \frac{D \times \pi \times n}{60 \times 1\,000}$$

where

n is the rotational speed in rotations per minute;

v is the peripheral speed in metres per second;

D is the outside diameter of the abrasive product in millimetres.

4 List of significant hazards

4.1 General

The manufacturer of the grinding machine shall conduct a risk assessment in accordance with ISO 12100. The list of hazards and hazardous situations in Table 2 is the result of task and hazard identification determined by risk assessment carried out in accordance with ISO 12100:2010, Clauses 4 and 5.4, for grinding machines covered by the Scope of this International Standard. The safety requirements and/or protective measures in Clauses 5 and 6 are based on the risk assessment and deal with the identified hazards by either eliminating them or reducing the risks they generate.

The risk assessment assumes foreseeable access from all directions, as well as unexpected start-up. Risks to both the operator(s) and other person(s) who can have access to the hazard zones are identified, taking into account hazards which can occur under various conditions (e.g. commissioning, set-up, production, maintenance, repair, and decommissioning) during the life of the machine. The assessment includes an analysis of the effect of failure in the control system.

In addition, the user of this International Standard (i.e. the designer, manufacturer and supplier) shall confirm through a risk assessment that the risk assessment is complete for the machine under consideration with particular attention to

a) the intended use of the machine including maintenance, setting and cleaning and its reasonably foreseeable misuse (see ISO 12100:2010, 3.23 and 3.24), and

b) the identification of the significant hazards associated with the machine.

4.2 Main hazard zones

The main hazard zones are the following:

a) work zones with moving axis(es) and wheel spindle(s) including truing spindle(s), workpiece holding device, work holding spindle(s), rest(s), tailstock, workpiece(s);

b) handling devices for workpiece loading/unloading;

c) internal and external tool magazines and tool changers;

d) gear box;

e) cam mechanisms.

4.3 Significant hazards and hazardous situations covered by this International Standard

The significant hazards covered by this International Standard are listed in Table 2. The numbering of the (sub)clauses in the table refers to the numbering in ISO 12100:2010, Table B.1.

Table 2 — List of significant hazards and hazardous situations

No.[a]	Causes for hazards and hazardous situations	Examples for hazardous situations and hazard zones at grinding machines	Possible consequences	Relevant (sub)clause in this International Standard
1	**Mechanical hazards**			
1.1	Approximation of a moving part to a fixed part	Manual activities in the area between abrasive product and parts of the grinding machine, particularly the work rest or between abrasive product and workpiece	Crushing Shearing Drawing-in Trapping	5.1.2 5.2 5.12
		Feed movement of the abrasive product to the workpiece	Crushing Shearing Ejected parts	5.1.2 5.2
		Manual activity in the vicinity of the abrasive product or the spindle	Entanglement	5.1.2 5.2
		Clamping of tools and workpieces	Crushing Shearing	
1.2	Moving parts	Activity in the area of travelling axes, moving machine parts, and in the area of automatic loading devices during machining, setting, maintenance, and repair. Reciprocating movement of the workpiece table. Activities in the area of working platforms	Impact Entanglement Drawing-in Trapping	5.1.2 5.2 5.9 5.12

Table 2 *(continued)*

No.[a]	Causes for hazards and hazardous situations	Examples for hazardous situations and hazard zones at grinding machines	Possible consequences	Relevant (sub)clause in this International Standard
1.3	Rotating parts	Unintended contact with the rotating abrasive product during loading and unloading and/or measuring	Friction Abrasion Drawing-in Trapping	5.1.2 5.2 5.9 5.10 5.12
1.4	Pointed and cutting parts Sharp edges	Unintended contact with sharp workpiece edges during loading and unloading and/or measuring	Cutting Puncture Friction Abrasion	5.1.2 5.2
1.5	Falling or ejected objects	Ejection or falling down of material parts and chips during start-up, setting, grinding operation, change of abrasive product, maintenance, or decommissioning Workpiece falling down; Rupture of abrasive product; Machine parts ejected after rupture at or in the vicinity of the machine	Crushing Shearing Impact Penetration Puncture	5.1.2 5.2 5.9 5.10 5.12 5.13 7.2.2 7.2.3 7.2.5
1.6	Gravity	Falling movable machine elements during setting, e.g. during abrasive product or workpiece change due to gravity. Activities in the area of working platforms or at pits	Crushing Shearing Impact	5.1.2 5.2 5.12
1.7	High pressure	At hydraulic components when staying at or in the vicinity of the machine, particularly during installation and commissioning of the machine	Penetration or impact of media under pressure into the skin/eyes	5.1.2 5.2
1.8	Stability	Falling or tipping of a non-fixed machine or of machine parts when staying at or in the vicinity of the machine	Impact Crushing	5.14 7.2.10
1.9	Rough, slippery surface	Activities in the floor and step area at and around the machine and work in a height due to — ejection or spillage of metalworking fluid, lubricants, or hydraulic fluid; — residues contained in ejected fluids; — insufficient railing or other containing devices, particularly at points, where there is a risk of falling.	Slipping Tipping Falling	5.1.2 5.2 5.15
2	**Electrical hazards**			
2.1	Live parts	Contact with live parts	Electric shock	5.3
2.2	Parts which have become live under fault conditions	Contact with parts which have become live under fault conditions	Electric contact	5.3

Table 2 *(continued)*

No.[a]	Causes for hazards and hazardous situations	Examples for hazardous situations and hazard zones at grinding machines	Possible consequences	Relevant (sub)clause in this International Standard
3	**Thermal hazards**			
	Objects or materials with high temperature	Ejection of hot grinding sparks during grinding when staying at or in the vicinity of the machine	Burns	5.1.2 5.2
4	**Noise hazards**			
	Manufacturing process and moving parts	Aerodynamic noise due to — the rotating abrasive product; — vibration of abrasive product and/or workpiece during grinding; — drive and transmission elements; — air blast for cleaning; when staying at or in the vicinity of the machine.	Permanent hearing loss Other (e.g. mechanical, electrical) hazards as a consequence of a disturbed voice communication or an interference of acoustic signals	5.4 7.2.6 Annex F Annex G
5	**Vibration hazards**			
	Vibrating parts	Transmissions of vibrations from the grinding process on the operator at machines for manually guided grinding	Discomfort Neurological disease Joint damages	5.5 7.2.7
6	**Radiation hazards**			
6.1	Low and high frequency electromagnetic radiation	During activities at electric equipment, particularly during setting or maintenance	Influence on active implants e.g. pacemakers, defibrillators	5.6
6.2	Optical radiation (infrared, visible and ultraviolet), including laser radiation	During activities at measuring devices and measuring lasers, particularly during setting or maintenance	Burning Eye damage	5.6
7	**Material/substances hazards**			
7.1	Biological and microbiological (viral or bacterial) agent	Contact with metalworking fluids contaminated with bacteria when staying at or in the vicinity of the machine	Infection	5.7.1
7.2	Liquid	Skin contact with metalworking fluids when staying at or in the vicinity of the machine	Skin damage	5.7.1 5.7.2
7.3	Vapours	Inhalation and intake of substances used or generated during machining, e.g. by metalworking fluids when staying at or in the vicinity of the machine	Breathing difficulties Poisoning	5.7.1 5.7.2
7.4	Fire hazardous material	Fire and explosion hazards a) during machining of flammable material, e.g. aluminium, magnesium b) during use of flammable material, e.g. oil containing metalworking fluid	Burns due to fire and explosion	5.7 5.7.3 Annex H Annex I Annex J
8	**Ergonomic hazards**			

Table 2 *(continued)*

No.[a]	Causes for hazards and hazardous situations	Examples for hazardous situations and hazard zones at grinding machines	Possible consequences	Relevant (sub)clause in this International Standard
8.1	Design or location of indicators and optical displays	Misjudgment of the indicated information at operator's position	Other (e.g. mechanical, electrical) hazards as a consequence of human error	5.8
8.2	Design, location or identification of control devices	Faulty operation of the machine at operator's position		5.8
8.3	Effort	At control devices and during handling Inadequate consideration of hand/arm or foot/leg anatomy during workpiece or tool change	Fatigue	5.8
8.4	Body posture		Disturbance of the musculoskeletal system	5.8
8.5	Repeated activities		Fatigue	5.8
8.6	Visibility, local lighting	Affection of the accuracy and the judgment ability of/for manual activities during handling and alignment of the workpiece and the abrasive product during loading/unloading, setting, abrasive product change, and maintenance at loading/unloading and changing points of the abrasive products	Fatigue Other (e.g. mechanical, electrical) hazards as a consequence of human error	5.8
9	**Hazards related to the environment in which the machine is used**			
	Human error	Reasonably foreseeable misuse, Incorrect operation of the machine (manipulations) Inappropriate handling and setting of the workpiece and the abrasive product Insufficient design of the workplace and/or machining process Inadequate consideration of hand/arm or foot/leg anatomy Incorrect installation	All hazards listed above	5.2.6 7.2.4 7.2.11
10	**Combination of hazards**			

Table 2 *(continued)*

No.[a]	Causes for hazards and hazardous situations	Examples for hazardous situations and hazard zones at grinding machines	Possible consequences	Relevant (sub)clause in this International Standard
10.1	Failure of power supply	Fall or ejection of moving machine parts or a mounted workpiece or tool or their fragments Failure of stop control for moving parts	Crushing Shearing Impact Cutting Cutting-off Drawing-in Trapping Penetration Puncture Friction Abrasion	5.9 5.11
10.2	Restoration of energy supply after an interruption	Uncontrolled movements (including speed variation) Unintended/unexpected start-up		5.9 5.10
10.3	Failure of control system	Falling or ejection of moving machine parts or a mounted workpiece or tool Failure of stop control for moving parts Uncontrolled movements (including speed variation) Unintended/unexpected start-up Other hazardous events due to failure or poor design of the control system Variation of speed of tools (during setting)		5.9 5.10 5.12

[a] Table 2 contains the hazards specific to grinding machines from Table B.1 in ISO 12100:2010, Annex B. The numbers of the clauses in this column also refer to that table.

5 Safety requirements and/or measures

5.1 General requirements

5.1.1 General

Grinding machines shall comply with the safety requirements and/or measures of Clause 5. For hazards which are not dealt with in this International Standard, the machines shall be designed in accordance with the principles of ISO 12100:2010, Clause 4 and 6.1.

For guidance in connection with risk reduction by design, see ISO 12100:2010, 6.2; for safeguarding measures, see ISO 12100:2010, 6.3.

The designer shall take into account hazards which can occur during the life of the machine to both operator and other persons who have access to the hazard zone(s) for conditions of intended use, including reasonably foreseeable misuse of the machine (see ISO 12100:2010, 3.23 and 3.24). The hazards for both machining operation and/or operations requiring intervention by the operator and/or other persons (e.g. setting, cleaning, maintenance and repair) shall be considered. An analysis of the failure of machine components, including failure in the control system(s), is part of the risk assessment and guidance on this subject is given in ISO 13849-1. Therefore, reliability requirements for safety functions are defined as performance level (PL), in accordance with ISO 13849-1 (see 5.12 b)).

All requirements and/or protective measures given in Clause 5 apply to all groups of grinding machines, unless specifically referenced.

5.1.2 Requirements for guards for all groups of grinding machines

5.1.2.1 General

Guards shall be in accordance with ISO 14120. The fixing systems of fixed guards shall remain attached to the guards or to the machinery when the guards are removed. The requirement does not necessarily apply to fixed guards, which, for instance, have only to be removed, when the machine is completely renewed, when more extensive repairs are necessary or when it is demounted to be transferred to another site.

5.1.2.2 Position and safety

The requirements are the following:

a) Height and position: where guards are floor-mounted (e.g. perimeter fencing), they shall be fixed securely and have a minimum height of 1,4 m. The distance from the hazard zone shall be in accordance with ISO 13857:2008, Table 2. Any opening between the bottom of the guard and the floor shall not exceed 180 mm.

b) For the guarding of drives, access to mechanical power transmission drives (e.g. chains and sprockets, gears, leadscrews, feedscrews and ballscrews etc.) shall be prevented, e.g. by fixed guards or by design, so that the hazardous zone is not accessible.

   If access to these parts is required during normal operation of the machine, interlocked movable guards shall be provided (see c)).

   NOTE Interlocked movable guards are not always necessary for group 1 and group 2 machines.

c) Interlocking of guards

   1) movable guards shall be interlocked with or without guard locking in accordance with ISO 14119 in order to prevent access to hazardous machine movements. The selection of interlocking devices shall be in accordance with ISO 14119:1998, Clause 7;

   2) a failure in the interlocking device, i.e. function and/or arrangements, shall result in a category 1 stop of the machine in accordance with IEC 60204-1:2009, 9.2.2;

   3) for requirements concerning safety functions of interlocking devices associated with movable guards, see 5.12 b) 1).

5.2 Specific requirements resulting from mechanical hazards identified in Table 2, Nos. 1.1 - 1.4, 1.6 and 1.7

5.2.1 Group 1 machines, manually controlled grinding machines without power operated axes and without numerical control

Requirements are the following:

a) The machines shall be provided with means of preventing unintended contact with the abrasive product. The complete abrasive product shall be guarded except that part necessarily exposed for the work.

This requirement is usually met by the abrasive product guard in accordance with 5.13.2.1.

b) In case of power controlled rough positioning, the speed of axes shall be 2 m/min. at maximum. Control of the movements shall be effected by means of a hold-to run device (see 5.12. b) 2)) or an electronic hand wheel (see 5.12 b) 3)).

c) For loading and unloading or measuring, additional equipment or precautions shall be provided or taken to prevent contact with the rotating abrasive product, except for machines, where the workpiece is guided by hand. These may include one or more of the following:

   1) stopping the rotation of the abrasive product;

   2) providing safeguards;

   3) positioning the abrasive product so that it cannot be reached by the operator (respect of safety distances, at least 200 mm between abrasive product and workpiece).

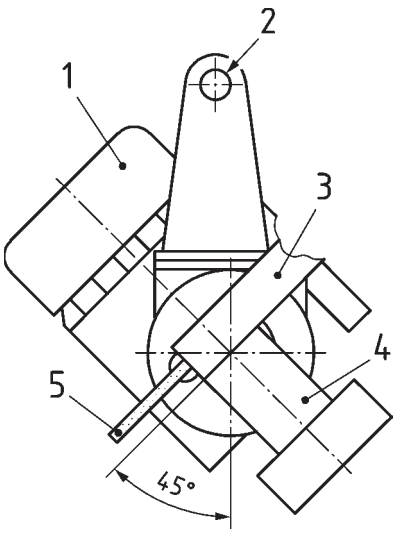
   NOTE Deviation from ISO 13857 due to small work zone.

d) Cutting-off machines for mechanically guided cutting-off in accordance with Table 1, No. 1.3 shall be provided with measures to ensure that the cutting-off wheel moves automatically back to its initial position after use. It shall remain in that position and be automatically guarded against contact until the cutting-off wheel has stopped.

e) Swing frame grinding and swing frame cutting-off machines in accordance with Table 1, No. 1.4 shall be equipped with an adjustable counterbalance weight so that the grinding head moves away from the workpiece after release of the handles.

f) At swing frame grinding machines for manually guided grinding, the grinding head can only be swivelled by up to 45° from the vertical axis on either side (see Figure 6).

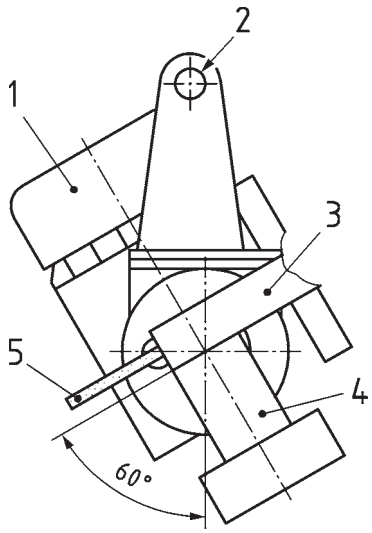
g) At swing frame cutting-off grinding machines for manually guided cutting-off, the grinding head can only be swivelled by up to 60° from the vertical axis on either side (see Figure 7).



Key

1 motor
2 suspension
3 guard
4 swivelling axis
5 grinding wheel

Figure 6 — Swing frame grinding machine



Key

1 motor
2 suspension
3 guard
4 swivelling axis
5 cutting-off wheel

Figure 7 — Swing frame cutting-off machine

h) Bench and pedestal grinding machines in accordance with Table 1, Nos. 1.1 and 1.2 shall be provided with a transparent screen for the protection of the face and especially the eyes of the operator against small grinding particles and grinding sparks.

The screens shall have sufficient resistance to impact and abrasion so that they do not break or crack in the case of impact load, e.g. during handling of workpieces, and that the surface abrasion caused by ejected abrasive grit and grinding sparks is minimised. Polycarbonate is an example for a suitable screen material.

The screen shall be adjustable and of sufficient size so that the operator in normal working positions can only view the grinding operation through the screen. The screen shall not impede guiding and holding of the workpieces.

The minimum dimensions of screens are given in A.3.4.

i) At Group 1 grinding machines, unintended start-up of the wheel spindle and, if applicable, the axis for rough positioning shall be prevented in accordance with ISO 14118:2000, Clause 6.

j) The wheel spindle may be operated if an abrasive product guard in accordance with 5.13.2.1 is provided and the peripheral speed of the abrasive product is limited to values $v \leq 50$m/s. For monitoring of the reduced spindle speed of the wheel spindle, see 5.12 b) 5). Rotation of the spindle shall only be initiated manually by a control device (e.g. a start button) provided for that purpose (see 5.12 b) 14)).

5.2.2 Group 2 machines, manually controlled grinding machines with power operated axes and, if applicable, with limited numerically controlled capability

Requirements are the following:

a) Protection against contact with abrasive products

The machines shall be provided with means of preventing unintended contact with the abrasive product. The complete abrasive product should be guarded except that part necessarily exposed for the work.

This requirement is usually met by the abrasive product guard in accordance with 5.13.2.1.

b) Access into the work zone

Group 2 grinding machines - except for machine tools with workpiece dimensions ≤ 300 mm - shall be equipped with fixed and/or movable guards at the rear and the sides of the work zone preventing access to hazards zones, including the machining point, and the ejection of metalworking fluid from the work zone. The minimum distances specified in ISO 13857 shall be complied with.

c) Reaching of trapping and entanglement points at rotating parts in the work zone, e.g. at chucks, workpieces, shall be prevented by fixed and/or movable guards.

d) Shearing and crushing points outside the work zone, e.g. between reciprocating table and stationary machine parts (including electrical cabinets) and at reciprocating switches (e.g. on surface grinding machines) shall be prevented by design or safeguarded.

e) For manual interventions, such as loading and unloading or measuring, additional equipment or precautions shall be provided or taken preventing contact with the rotating abrasive product. These may include one or more of the following:

1) stopping the rotation of the abrasive product;

2) providing an automatic safeguard;

3) positioning the abrasive product so that it cannot be reached by the operator (respect of safety distances, at least 200 mm between abrasive product and workpiece).

NOTE Deviation from ISO 13857 due to small work zone.

f) Mode of safe operation

Only MSO 0 in accordance with 5.2.7.2 is permitted. Deviating from 5.2.7.2 c), the reduced axis speed of the reciprocating movement longitudinal to the table may be 25 m/min at maximum at surface grinding machines, if only a striking hazard exists.

g) Hazard of entrapment, trapping, and impact resulting from power rotation of handwheels shall be prevented, e.g. by automatic disengagement or by using plain solid (no spokes) handwheels with either no pegs or sprung to safe position pegs.

5.2.3 Group 3 machines, numerically controlled grinding machines

5.2.3.1 Access to the work zone

Guards shall be provided to mitigate the risks listed in Table 2 (entanglement, crushing, shearing, etc.) by preventing access to dangerous parts of the machines. General guidance for the selection of safeguards, where the hazards from moving parts cannot be avoided by design is given in ISO 12100:2010, 6.3.2, 6.3.3. For the features of guards to minimize the hazard of ejection, see 5.13.

5.2.3.2 Specific requirements for guards

The specific requirements for guards for Group 3 machines are the following:

a) Interlocking of guards

1) All guards through which frequent access to hazardous movement is required during operation shall be designed as interlocked movable guards (see as well 5.1.2.2 c)). Opening of a movable guard or actuation of a protective device shall cause hazardous movements to stop and further movement to be inhibited (see ISO 14118). If the movable guards provide access to the work zone and hazards by follow-up movements arise, they shall be additionally equipped with guard locking. Measures to minimize the possible defeat of interlocking device(s) shall be taken (see ISO 14119:1998, Clause 5 and Clause 7).

2) When persons can have whole body access or can remain in the hazardous zone(s) without being visible to the operator, a means to inhibit restart shall be provided, e.g. presence-sensing protective equipment or door closure inhibition by captive keys.

NOTE Captive key is an interlocking device allowing the door unlock after initiation of stopping function for dangerous movements by its key.

b) Power operated guards

1) The requirements of 5.2.3.2 a) shall also apply.

2) If power operated guards for operator access are provided, they shall be in accordance with ISO 12100:2010, 6.3.3.2.6 and shall be equipped with a protective device to avoid shearing and crushing hazards at the front edge. If pressure-sensitive edges are provided, they shall be fitted on the total length of the front edge or up to a height of 2,50 m above the floor or platform, if the height of the guard is more than 2,50 m. The pressure-sensitive edge shall be in accordance with ISO 13856-2. The safety function of the guard shall comply with 5.12 b) 9).

3) The force to prevent the door from closing shall not exceed 75 N and the kinetic energy of the guard shall not exceed 4 J. When the guard is fitted with a protective device which automatically initiates reopening of the guard on actuation, this may be a maximum of 150 N and the kinetic energy a maximum of 10 J (see ISO 14120:2002, 5.2.5.2). These requirements only apply under the assumption that the front edges have a minimum width of 8 mm and that no shearing movement occurs. At the side edge between movable guard and housing, a gap width of 4 mm shall not be exceeded.

4) If the requirements of b) 2 and b) 3) cannot be met, another fixed position protective device, e.g. a two-hand control device, shall be provided.

5) It shall not be possible to start the movement of the machine until the guard is fully closed. Closing of the guard can be used as a start command for the machine, when the guard system meets the requirements of ISO 12100:2010, 6.3.3.2.5.

6) These requirements shall only apply for guards as defined in ISO 12100:2010, 3.27.

5.2.3.3 Additional specific requirements

Additional specific requirements for Group 3 machines are the following:

a) Access into the work zone is allowed according to the requirements in 5.2.7 on modes of machine operation.

b) Guards shall also be designed to contain and/or prevent exposure to grinding debris, fluids and parts that can be ejected (see also 5.13 and 5.15 b)).

c) Contact protection

For manual interventions in MSO 1 such as loading and unloading or measuring, additional equipment or precautions shall be provided or taken preventing contact with the rotating abrasive product. These can include the following:

1) stopping the rotation of the abrasive product

2) providing an automatic safeguard;

3) positioning the abrasive product so that it cannot be reached by the operator (respect of safety distances in ISO 13857).

d) Mode of safe operation

MSO 1 and MSO 2 are mandatory for this machine group. MSO 0, MSO 3, and MSO service are optional.

e) For MSO 0, the requirements for Group 2 machines shall apply (see 5.2.2).

5.2.4 Tool holding device

Tool holding devices shall be designed so that there is no clamping loss during operation including acceleration and deceleration.

For clamping methods for abrasive products and safety requirements for tool holding devices, see Annexe D and Annex E.

5.2.5 Workpiece holding

5.2.5.1 General

Grinding machines shall be provided with clamping devices, holding or guiding the workpieces to prevent them from inadvertent movement. Opening and closing of the workpiece holding devices for manual workpiece change can be possible in all modes of safe operation.

5.2.5.2 Workpiece rests

a) Grinding machines without workpiece holding device (compare Table 1 No. 1.1 and 1.2) shall be provided with workpiece rests capable of accommodating safely the forces generated.

b) The workpiece rests shall be adjustable with respect to the wear of the abrasive product so that the distance between the abrasive product and the workpiece rest will not exceed 2 mm. It shall be of at least the same width as the abrasive product for which the grinding machine was designed and it shall be of substantial construction and securely attached to the grinding machine.

5.2.5.3 Power operated workpiece holding devices

a) Grinding machines with power operated clamping devices shall be equipped so that in the case of clamping energy losses or if the actuating force of the clamping device falls below a pre-set minimum value, the machining process is prevented or a machine stop category 1 in accordance with IEC 60204-1 shall be initiated. For rotating workpiece holding devices, a rotation of the power operated work holding spindle without or with reduced actuating force is permitted for positioning of the workpiece in exceptional cases, if there is no hazard caused by ejection of the workpiece. The reduced spindle speed of the work holding spindle for the relevant mode of safe operation shall not be exceeded.

b) Efficiency of the actuating function shall be monitored, e.g. monitoring of the clamping pressure and/or the clamping travel (see 5.12 b) 7)).

c) At rotating workpiece holding devices, opening of the clamping device shall not be possible with rotating work holding spindle (see 5.12 b) 7)).

d) For manual loading, injuries of the fingers during operation of the clamping device shall be avoided[pre-setting of a maximum jaw stroke < 4 mm (see ISO 13857)].

e) Rotating workpiece holding devices shall be clearly marked with their maximum permissible speed.

f) The status of the clamping device shall be signalled to the operator.

In the event of a failure or interruption of the clamping energy, the clamping function shall be kept or the design of the grinding machine or the guard shall ensure that no parts can be ejected.

5.2.6 Vertical or slant axes under gravity

Means shall be provided to prevent hazardous movement of vertical or slant axes under gravity (e.g. brake system). For requirements concerning the safety function control for the prevention of unintended descent of vertical or slant axes, see 5.12 b) 13).

5.2.7 Modes of machine operation

5.2.7.1 Mode selection

a) The modes of safe operation which are mandatory or optional for the specific grinding machine are given in 5.2.2. f) and 5.2.3.3 d).

b) To select a mode

1) The selection of a mode of safe operation shall be either by key switch, access code or other equally secure means and shall only be permitted from outside the work zone. The selected mode shall be easily visible (e.g. by display or by position of the selector switch). Selection of a mode shall not initiate a hazardous situation. If a lockable mode selection switch is used, it shall be in accordance with ISO 12100:2010, 6.2.11.10 and IEC 60204-1:2009, 9.2.3.

2) The mode selection device and the associated control system arrangements shall ensure that only one mode is selected and enabled at any one time. For requirements concerning safety function for mode selection, see 5.12 b) 10).

3) For the selection of MSO 3 (see 5.2.7.5), a separate device is necessary, which shall meet the requirements under 1) and 2).

5.2.7.2 MSO 0: Manual mode

When MSO 0 is selected and the movable guards are open or when machines do not require guards against mechanical hazards as specified in 5.2, the following requirements apply:

a) The wheel spindle may be operated if an abrasive product guard in accordance with 5.13.2.1 is provided and the peripheral speed of the abrasive product is limited to values $v \leq 50$ m/s. For monitoring of the reduced speed of the wheel spindle, see 5.12 b) 5). Rotation of the spindle shall only be initiated manually by a control device (e.g. a start button) provided for that purpose (see 5.12 b) 14));

b) The feed movement between abrasive product and workpiece shall be effected manually. At maximum, 2 axis movements, which may also be numerically controlled, may be initiated simultaneously by a start button (see 5.12. b) 14)) while the wheel spindle is rotating. The infeed movements of all other axes may be effected manually by hand wheels, power operated by electronic hand wheels (see 5.12 b) 3)) or by hold-to-run devices (see 5.12 b) 2));

c) Axes shall move at a reduced speed as follows (see 5.12 b) 6)):

1) 2 m/min at maximum,

2) 5 m/min at maximum for a travel of more than 1 m up to 5 m, and

3) 10 m/min at maximum for a travel of more than 5 m in combination with a protective device (e.g. a two hand control device or a pressure-sensitive mat) ensuring the operator is standing in a safe position;

d) The peripheral speed of the work holding spindle(s) shall be limited to 0,7 m/s at maximum for clamping devices or workpieces up to a diameter of 500 mm. For larger diameters, limitation to 1,3 m/s at maximum peripheral speed shall be applied, but not more than 50 min^{-1} at the reduced speed. For monitoring of the reduced speed of the work holding spindle, see 5.12 b) 5).

NOTE The values for the reduced speed of the feed, rotational, and periphery given in a), c), and d) are maximum values. In the framework of the risk assessment, they are reduced in accordance with the machine-specific hazardous situation, if applicable.

5.2.7.3 MSO 1: Automatic mode

When MSO 1 is selected and the movable guards are open, the following requirements apply:

a) No movement of machine elements shall be possible, and all axes and spindles shall be in safe stop (see 5.12 b) 12)) or safe operational stop (see 5.12 b) 11)). Exceptions are the following movements:

1) For manual workpiece holding, see 5.2.5.

2) Workpiece spindle(s) rotation shall be controlled by hold-to-run control [see 5.12 b) 2)] and shall not exceed 5 min^{-1} and the peripheral speed shall not exceed 5 m/min for the largest standard work holding device described in the instruction for use. The reduced speed shall be monitored [see 5.12 b) 5)].

3) The wheel spindle may be operated, providing

— the peripheral speed of the abrasive products shall be limited to $v \leq 50$ m/s, where the requirements of 5.2.3.3 c) (contact protection) and 5.13.2.1 (abrasive product guard) are met, or

— the peripheral speed of the abrasive product shall be limited to $v \leq 16$ m/s, where the abrasive product guard according to 5.13.2.1 is not provided and the requirements of 5.2.3.3 c) are not met.

For monitoring of the reduced speed of the wheel spindle, see 5.12 b) 5).

NOTE For manual clearing of the chip spaces of the abrasive product by means of a dressing stone, the requirement for contact protection can be met by means of personal protective equipment subject to the result of a risk assessment, if applicable (see Clause 7).

When MSO 1 is selected and the movable guards are closed, all programmed movements of machine elements are possible and the machine shall only be started or restarted by actuation of the start device. The monitoring of the maximum permissible speed of the wheel spindle shall be active (see 5.12 b) 5)); (exception: mains operated asynchronous motor).

5.2.7.4 MSO 2: Setting mode

This operating mode is not intended for machining.

When MSO 2 is selected and the movable guards are open, the following requirements apply:

a) The wheel spindle may be operated using a starting device, providing

— the peripheral speed of the abrasive products shall be limited to $v \leq 50$ m/s, where the requirements of 5.2.3.3 c) (contact protection) and 5.13.2.1 (abrasive product guard) are met, or

— the peripheral speed of the abrasive product shall be limited to $v \leq 16$ m/s, where the abrasive product guard according to 5.13.2.1 is not provided and the requirements of 5.2.3.3 c) are not met.

For monitoring the reduced speed of the wheel spindle see 5.12 b) 5).

b) Axes shall move at a reduced speed as follows (see 5.12 b) 6)):

1) 2 m/min at maximum;

2) 5 m/min at maximum for a travel of more than 1 m up to 5 m;

3) 10 m/min at maximum for a travel of more than 5 m in combination with a protective device (e.g. a two hand control device or a pressure-sensitive mat) ensuring the operator is standing in a safe position.

Control of the movements shall be effected by means of a hold-to run device (see 5.12. b) 2)) or an electronic hand wheel (see 5.12 b) 3)).

For the hold-to-run device or the electronic hand wheel, a PL_r lower than specified in 5.12. b) is sufficient, if there is a realistic chance to avoid the hazard. This can be assumed, if the reduced speed of the axes is limited to a value below 0,5 m/min (see 5.12 b) 6)).

c) Limitation of the speed of power operated work holding spindle(s) to $n \leq 50\ \text{min}^{-1}$ but not more than 1,3 m/s, measured at the diameter of the clamping device or, if the workpiece diameter is larger, at the largest workpiece diameter. For monitoring of the reduced speed of the work holding spindle, see 5.12 b) 5). Control of the movement shall be effected by means of a hold-to-run device (see 5.12 b) 2)) or an electronic hand wheel (see 5. 12 b) 3)) or by means of a start button in combination with an enabling device (see 5.12 b) 4)).

The hold-to-run device may also be designed as a two-step foot switch for ergonomic reasons (see 5.12 b 2)).

For the hold-to-run device or the electronic hand wheel, a PL_r lower than specified in 5.12 b) is sufficient, if there is a realistic chance that the severity of the injury to be expected is low. This can be assumed, if no trapping, entanglement, drawing-in hazards, etc. are present.

NOTE The values for the reduced speeds of the feed, rotation, and periphery given in a) to c) are maximum values. In the framework of the risk assessment, they are reduced in accordance with the machine-specific hazardous situation, if applicable.

d) When access is given to a hazard zone from more than one position through movable guard(s) and part of the hazard zone is not visible from the operator's position, no movement shall be possible unless the remaining guards at these hazard zones are closed

e) If the machine is equipped with handling devices for workpiece and tool loading/unloading:

1) For handling device setting, the requirements specified under b) or the requirements in ISO 10218-1:2006, 5.7.3 and 5.7.4 apply, even if the handling device is only programmable in less than three axes;

2) If the axes speed cannot exceed the limits (e.g. on pneumatic axes), monitoring of the reduced speed according to 5.12 b) 6) with guard open is not required. Power operated motion shall only be initiated under control of an enabling device together with a hold-to-run device to permit step-by-step movement. When continuous movement is required, the enabling device and the hold-to-run device shall be at a safe distance from the hazardous situation to keep both hands outside the hazardous zone (see ISO 13855). For requirements concerning the safety functions, e.g. hold-to run control and enabling device, see 5.12 b) 2) and 4). No hazardous movement shall arise from the actuation of any sensor or feedback device;

3) If a robot is used for workpiece loading/unloading, the requirements of ISO 10218-1 shall apply.

When MSO 2 is selected and the movable guards are closed, all movements of machine elements are possible. Monitoring of the maximum permissible speed of the wheel spindle shall be active (see 5.12 b) 5); (exception: mains operated asynchronous motor).

5.2.7.5 MSO 3: optional special mode for manual intervention under restricted operating conditions

This operating mode is only intended, where access for the operator to the danger zone is absolutely necessary, and provided that all safety measures applicable under technological aspects and feasible in accordance with the state of the art are carried out. Access for the operator can be absolutely necessary in the case of production of single items and small production series with high precision and complexity. Furthermore, automatic program runs with guards opened are required for first program testing with complex workpiece and tool arrangements.

If MSO 3 is selected and the guards are open, the requirements according to 5.2.7.4 (MSO 2: setting mode) apply to manual operation, and the following requirements apply to execute programmed cycles:

a) The wheel spindle may be operated, providing

   — the peripheral speed of the abrasive products shall be limited to $v \leq 50$ m/s, where the requirements of 5.2.3.3 c) (contact protection) and 5.13.2.1 (abrasive product guard) are met, or

   — the peripheral speed of the abrasive product shall be limited to $v \leq 16$ m/s, where the abrasive product guard according to 5.13.2.1 is not provided and the requirements of 5.2.3.3 c) are not met.

   For monitoring of the reduced speed of the wheel spindle, see 5.12 b) 5).

b) Axes shall move at a reduced speed as follows (see 5.12 b) 6)):

   1) 2 m/min at maximum;

   2) 5 m/min at maximum for a travel of more than 1 m.

c) The peripheral speed of the work holding spindle(s) shall be limited to 0,7 m/s at maximum for clamping devices or workpieces up to a diameter of 500 mm. For larger diameters, limitation to 1,3 m/s at maximum peripheral speed shall be applied, but not more than 50 min^{-1} at the reduced speed. For monitoring of the reduced speed of the work holding spindle, see 5.12 b) 5).

   NOTE The values for the reduced speeds of the feed, rotation, and periphery given in a) to c) are maximum values. In the framework of the risk assessment, they are reduced in accordance with the machine-specific hazardous situation, if applicable.

d) Control of the programmed movements under b) and c) can be effected by a hold-to-run device (see 5.12 b) 2)) or with an electronic hand wheel (see 5.12 b) 3)) or with start button, each in combination with an enabling device.

e) Access to the danger zone created by moving clamping devices, e.g. rotating protruding jaws on chucks, shall be prevented by guards.

f) A started program cycle shall be displayed throughout the whole cycle. The next step prior to execution shall also be displayed.

Requirements of 5.3 to 5.15 shall additionally be met. Examples for applications where MSO 3 is required are given in Annex K.

When MSO 3 is selected and the movable guards are closed, all movements of machine elements are possible without enabling device. Monitoring of the reduced speed of the wheel spindle shall be active (see 5.12 b) 5)).

5.2.7.6 MSO service

MSO service shall only be provided for service staff, trained and authorized by the machine manufacturer, and for staff qualified by the client in accordance with the instructions of the machine manufacturer (see as well 7.2.9).

a) General

   1) For the selection of MSO service, a lockable switch mounted on a cable connected, detachable service device shall be provided. The connection of the service device shall be accessible at the machine, e.g. at the outside of an electric enclosure. Warning signs at the service device shall inform that the use of the service device is restricted to service staff, trained and authorized by the machine manufacturer. As long as the service device is connected to the machine, no other mode of safe operation shall be selectable. The instructions for use shall require removing the device after completing service activities

   The service device may be replaced by other selection devices limiting application of MSO service to the persons mentioned above.

   2) Manual operation shall be possible under the conditions in 5.2.7.4.

   3) According to the risk assessment, additional safety measures can be necessary, such as secondary guards, barriers, or screens, in connection with warning signs.

b) This mode will enable restricted automatic functionality of the machine with the movable guards open. The restrictions are the following:

   1) machining shall not be possible in MSO service;

   2) axes speed shall be reduced and monitored (see 5.12 b) 6)) with the exception of cases according to 5.2.7.6 b) 5). These reduced axes speed shall not exceed 2 m/min, or 5 m/min for axes with traverse of more than 1 m;

   3) Continued moving cycles can be possible (e.g. repeatability test);

   4) Rotation of the wheel and work holding spindles shall be possible under the conditions in 5.2.7.5 a) and c);

   5) Control of the programmed movements may be effected by a hold-to-run device (see 5.12 b) 2)) or with an electronic hand wheel (see 5.12 b) 3)) or with start button, each in combination with an enabling device. This enabling device shall be placed outside the hazard zone, if the reduced speed is exceeded according to 5.2.7.6 b) 2).

5.2.8 Optional or additional equipment for grinding machines

5.2.8.1 Handling devices for workpiece loading/unloading

If the machine is equipped with handling devices for workpiece loading/unloading, the following requirements shall be fulfilled.

a) Load/unload positions for operators at workpiece transfer devices shall be located outside the work zone and away from the other hazardous mechanism (e.g. the tool changer).

b) Access to the hazardous movements of handling devices shall be prevented by means of fixed and/or interlocked movable guards (see 5.12 b) 1) iv)) or hazardous movement(s) shall be either stopped or inhibited by the actuation of protective devices (e.g. interlocked guard or light curtain).

c) For requirements concerning setting mode of handling devices for workpiece loading/unloading, see 5.2.7.4 e).

d) Actuation of a machine's emergency stop device (see 5.12 c)) shall also initiate the emergency stop function of the handling device and vice versa, if the loader is in the machine area. If the machine and the loader form one integrated manufacturing system, ISO 11161 shall be applied.

e) If access to the handling device hazard zone is possible, access from that area to the machine work zone

— is either impossible, or

— the machine shall be in stopped condition and unexpected start-up shall be prevented.

f) If access to the work zone of the machine is possible, access to the handling device

— is either impossible, or

— the handling device shall be in stopped condition and unexpected start-up shall be prevented (for prevention of unexpected start-up, see ISO 14118).

5.2.8.2 Machines equipped with a tailstock and/or quill

If the machine is equipped with a tailstock and/or quill, means shall be provided to prevent the tailstock being unintentionally pulled off the end of the bed during manual adjustment of its position (e.g. mechanical stop). For machines with power operated tailstock and/or quill:

a) Power operated movements of the quill when the guard is open, with the exception of spring-actuated quills, shall not exceed 1,2 m/min when the stroke is >10 mm and shall only be possible by using one of the following devices:

   1) a control device requiring both hands outside the work zone (e.g. by two-hand control in accordance with ISO 13851; see 5.12 b) 2)),

   2) a hold-to-run control, (see 5.12 b) 2)), or

   3) a 2-position or 3-position-foot switch; see 5.12. b) 2).

b) Means to adjust the clamping force are recommended. If the clamping system is not activated or not closed, a process start shall be inhibited. The process shall be stopped (e.g. controlled stop) if the clamping system opens unintended (e.g. initiation of the opening mechanism or a minimum clamping force level predefined by the operator is not reached) (see 5.12 b) 7)).

c) Opening and closing of the tailstock quill for manual workpiece change may be possible in all modes of safe operation.

d) Manual initiation of power operated tailstock and power operated quill movements shall not be possible when the work holding spindle is rotating (see 5.12 b) 7)), if the holding force of chuck or steady rest is not sufficient.

e) The clamping limit shall be

   1) indicated on the tailstock quill and the end position of the quill shall be durably indicated (e.g. by a coloured ring), or

   2) monitored by a limit switch which is interlocked with the spindle rotation (see 5.12 b) 7)).

f) Power operated movement of the tailstock body towards to the workpiece when the guard is open in all modes of safe operation shall only be possible by using a hold-to-run control (see 5.12 b) 2)). The tailstock body can retract to the defined position by one operation considering ISO 13854 for the necessary gaps to avoid crushing. The maximum traverse rate of the tailstock body shall not exceed 2 m/min.

5.2.8.3 Externally accessible tool magazine, tool-transfer, and tool-changing mechanism

If the machine is equipped with an externally accessible tool magazine, tool transfer, or tool changing mechanism, the following requirements shall apply.

a) Access to an externally accessible tool magazine and tool transfer and tool changing mechanism shall be safeguarded by a combination of fixed and movable guards (see 5.2.3.2 a)) in accordance with ISO 14119:1998, 7.1. For requirements concerning safety functions for interlocking devices associated with tool changer, tool magazine, see 5.12 b) 1) iii).

b) When the movable guard(s) for access to the tool magazine is (are) open, the tool magazine drive shall be stopped in safe stop or safe operational stop according to 5.12 b) 11) and 5.12 b) 12). In MSO 2, MSO 3, and in MSO service with the movable guard(s) open, power operated movement of the tool magazine (e.g. for tool replenishment, maintenance, or adjustment purposes) shall only be possible by means of hold-to-run control allowing a single tool station index movement or by two-hand control device (see ISO 13851) for continuous movement. This movement shall be at a reduced speed of 2 m/min or initiated from control devices located outside the reach of hazardous movements in accordance with ISO 13857.

c) In order to prevent falling or ejection of tools, they shall be held within the tool holder of the magazine. The design data for tool holding (e.g. limits for maximum mass, moments of inertia, and spatial envelope of tools) shall be provided to the user (see 7.2.2).

d) Fixed or movable guards shall prevent access to movable parts of the tool changer. When movable guards providing access to the tool changer from any hazard zone are open, the movement of the tool changer shall be inhibited. No hazardous machine movements shall arise from the actuation of any sensor or feed-back device. To prevent falling or ejection of tools, they shall be held in the tool changer under all operating conditions including loss of power.

5.3 Specific requirements resulting from electrical hazards

a) Direct contact with electrical equipment

   1) Electrical equipment shall be in accordance with IEC 60204-1, unless otherwise specified in this International Standard.

   2) See IEC 60204-1:2009, Clause 6, for the prevention of electric shock and IEC 60204-1:2009, Clause 7, for protection against short circuits and for protection against overloading. In particular, the following requirements in the relevant clauses of IEC 60204-1:2009 shall be fulfilled:

      i) Clause 7 for protection of equipment;

      ii) Clause 8 for equi-potential bonding;

      iii) Clause 12 for conductors and cables;

      iv) Clause 13 for wiring practices;

      v) Clause 14 for electrical motors and associated equipment.

   3) Electrical enclosures shall not be exposed to the risk of damage from the ejection of tools and/or workpieces. Live parts shall not be accessible (see IEC 60204-1:2009, 6.2.2). The risk of fire caused by faults in the electrical equipment is not considered significant on the machine where power circuits are protected against over current (see IEC 60204-1:2009, 7.2.2).

b) For indirect contact with electrical equipment, the requirements of IEC 60204-1:2009, 6.3 shall be fulfilled.

   NOTE See IEC 60204–1:2009, 3.27 for the definition of “indirect contact”.

c) For the protection of control gear, enclosures of control gear shall provide a degree of protection of at least IP2X, in accordance with IEC 60204-1:2009, 6.2.2, except for control gear enclosures within the work zone that shall be protected to IP55.

5.4 Specific requirements resulting from noise hazards

When designing the machine, the available information and technical measures to control noise at its source shall be taken into account (see, for example, ISO/TR 11688-1).

NOTE The main noise sources at grinding machines depend on the grinding method and the components and equipment used on the grinding machine. Sources of airborne noise include the following:

— abrasive products and workpieces;

— wheel spindles;

— work holding spindles;

— axis drives;

— ball screws;

— dressing and truing devices;

— loading, unloading, ejection, and transfer operations;

— hydraulic systems;

— extraction systems;

— pneumatic systems;

— metalworking fluid systems.

If means for the noise reduction at source are insufficient, secondary noise reduction measures shall be taken wherever possible. For measures for noise reduction, see Annex E.

For determination of noise emission, see Annex F.

The declaration of the noise emission values shall be in accordance with 7.2.6.

5.5 Specific requirements resulting from vibration hazards

On grinding machines with manually guided tool feed using a handle, for examples, see Table 1, Nos. 1.3 and 1.4, where operators can be subject to vibrations of more than 2,5 m/s^2, measures for preventing vibrations shall be taken. Measures for the reduction of vibrations can be achieved by construction and design, damping, and/or insulation (see CR 1030-1). For measurement of mechanical vibrations, see ISO 20643.

5.6 Specific requirements resulting from radiation hazards

a) For low-frequency radiation, radio frequency radiation, all microwaves, see 5.9 k). See also EN 12198-1, EN 12198-2 and EN 12198-3 for more information.

b) Built-in laser feedback systems shall be designed to prevent exposure to beam paths or specular reflections in accordance with IEC 60825-1.

5.7 Specific requirements resulting from materials or substance hazards

5.7.1 General

Materials or substances used for the construction and operation of grinding machines shall be chosen in such a way that no health hazardous effects occur over the life of the grinding machines, e.g. asbestos shall not be used for brake and clutch lining.

Where material hazardous to health is machined or used or where dusts, fumes, and mists are likely to be generated, the safeguards shall be designed to minimize operator exposure. An integral extraction system and/or means of fitting an extraction system shall be provided.

Grinding machines with an integral extraction system shall be designed so that the extraction is activated as soon as functions likely to generate dusts, fumes, and mists are switched on. After switching off these functions, the extraction system shall continue to run until hazards caused by dusts, fumes, and mists no longer exist. For totally enclosed machines, the after-run period depends on the volume of the workroom and on the extraction capacity, e.g. it should only be possible to open the guards after the air in the workroom has been exchanged at least twice. The integral extraction system shall be designed such that no exposure on hazardous substance on a dangerous level is possible, when the guards will be opened.

Measures shall be provided to prevent the escape of harmful mist, e.g. resulting from the use of compressed air.

As the actual requirements for the extraction system will depend on a variety of different parameters, e.g. the nature of the materials being used, it is not possible to give more detailed technical requirements in this International Standard.

5.7.2 Devices for the use of metalworking fluids

5.7.2.1 General

Where metalworking fluids for cooling and lubrication are used during grinding which can cause hazards to health, the grinding machine shall be provided with devices for the prevention or minimization of these hazards.

5.7.2.2 Measures for the protection against contact or inhalation

a) The system shall be designed to prevent splash, overflow, and leakage of the metalworking fluid.

b) Fluid reservoirs and other system components shall be made of materials to ensure the continued integrity of the system.

c) The delivery nozzles shall be designed so that unwanted spray is minimized.

d) Where the generation of mists and vapours in the work zone is foreseen, guards and an extraction system shall be provided or means for attachment of such a system (see 5.7.1).

e) The metalworking fluid shall have a capacity for the correct function of the grinding machine to avoid excessive heating and subsequent evaporation of the fluid. Alternatively, cooling systems shall be provided.

f) Where it is foreseen to be necessary for operators to place their hands into the work zone (e.g. during load/unload operations, setting, etc.), the metalworking fluid flow into the work zone shall be automatically stopped (see 5.12. b) 19)), when the guards are opened. Adjustment of metalworking fluid flow for the cooling of components or for bed flushing may be possible, e.g. for adjustment of nozzles. All other machines without automatic fluid control shall be provided with devices for manual control or diversion of the metalworking fluid supply.

g) Fluid reservoirs shall be fitted with clearly readable fluid level indicators marked with minimum/maximum filling levels.

h) The metalworking fluid system shall be capable of delivering metalworking fluid in a quantity to prevent the generation of hazardous vapours or aerosols during all foreseeable operating/grinding conditions.

i) The metalworking fluid system shall be designed to facilitate maintenance including sampling and to reduce as far as possible the exposure of personnel to the metalworking fluid during maintenance.

j) The grinding machine shall be designed so that grinding residues can be removed without requiring drainage of the whole system.

5.7.2.3 Biological and microbiological hazards (viral or bacterial)

a) The total content of the metalworking fluid systems shall be circulated in normal use so that no stationary volume within the tank exists except where settlement is required by design.

b) To avoid stagnant areas remaining within the machine, metalworking fluid shall drain from the machine towards the tank under gravity.

c) Discharge pipework shall have sufficient diameter and slope to minimize sludge settlement.

d) The metalworking fluid system shall be provided with filtration.

e) When sediment build-up occurs, cleaning shall be taken into account (e.g. rounded corners in containers). Cleaning shall not require drainage of the whole system (see ISO 14159).

f) The inside of tanks shall not contribute to the growth of bacteria (e.g. smooth surfaces).

g) Metalworking fluid containers shall have covers designed to prevent the ingress of foreign matter.

h) Contamination of the metalworking fluid by oil or grease from external sources such as lost machine lubrication shall be avoided or means shall be provided for their systematic removal. It should be possible to add a separation or removal system for oil or grease, if necessary.

i) Where a grinding machine is provided with enclosed guards used with metalworking fluid, the enclosure shall be designed to provide an interface between the guard enclosure and an extraction system. The positioning of the interface should take into consideration the internal airflows generated by the machine when in normal operation to enable effective operation of the extraction system.

5.7.3 Measures against fire and explosion hazards

5.7.3.1 Flammable metalworking fluids

5.7.3.1.1 Requirements on metalworking fluids systems

Grinding machines designed for the use of flammable metalworking fluids shall be provided with the following devices minimizing the risk of generation of flammable mixtures and ignition sources.

a) Metalworking fluid circuit shall be designed in such a way (pipe cross-section, storage container, pumps, nozzle types and positioning options etc.) to ensure sufficient quantities of metalworking fluid at the machining point at any time and for any tool.

b) If the metalworking fluid supply is not functioning, start-up of the machine shall be prevented. For monitoring of the metalworking fluid supply, see 5.12 b) 18).

c) In case of malfunction of the metalworking fluid supply, the process shall be stopped automatically in an appropriate manner, e.g. separation of tool and workpiece and disconnection of wheel spindle and extraction system.

d) Suitable extraction systems shall be provided.

5.7.3.1.2 Requirements on extraction systems

The extraction efficiency shall at least ensure maintenance of negative pressure in the workroom in order to safely prevent egress of metalworking fluid vapours and aerosols from the machine.

If the extraction system is not properly functioning, starting of the operating cycle of the machine shall be prevented (see 5.12 b) 18)) or a machining process under way shall automatically be stopped by appropriate means, e.g. separation of tool and workpiece and disconnection of wheel spindle and tool drives.

All metal bodies in the workroom, including the extraction system pipework, shall be continuously connected to the protective conductor system.

If fire and explosion hazards cannot be prevented by these means, additional measures to limit the effects of fire and explosion events shall be taken.

Such measures include the following:

1) Pressure-resistant workroom enclosure including vision panels and pressure relief, where required, in a direction presenting no hazard to persons. The pressure-resistant workroom enclosure shall also fulfil the requirements for guards specified in 5.1.2 and, if applicable, in 5.2.3.2. For information on the dimensioning of pressure relief surfaces, see Annex H.

2) Prevention of the escaping of flames and hot gases into the operating area and the environment of the machine, e.g. by flame-proof labyrinth seals at movable parts of the guards (circumferential). For examples, see Annex H.

3) Fire extinguishing devices (for technical control requirements for fire alarm and automatic fire extinguishing systems, see 5.12 b) 16) and 17)).

4) The machine, including the control system, shall be so designed that connection to devices for fire detection, fire extinguishing systems, fire alarm, pressure relief devices, etc. according to the manufacturer's recommendations is possible.

For machines intended for being connected to a central extraction system, measures or systems shall be provided, preventing, in case of a fire,

— fire propagation into the central extraction system,

— further air supply into the machining room, and

— extraction of extinguishing medium.

NOTE 1 E.g. use of flame arresters (for an example see Annex H), exhaust air shut-off valves.

Integral extraction systems shall automatically shut-off in case of a fire or explosion.

For examples for the integration of extraction and fire extinguishing systems when using flammable metalworking fluids, see Annex I.

NOTE 2 Further measures for risk reduction depend on the actual conditions of use of the machine and shall be considered for the individual case.

5.7.3.2 Flammable and explosive dusts

Where grinding machines are designed for the machining of materials which can generate flammable and explosive dusts (e.g. aluminium, magnesium, and their alloys), devices for the safe removal of these dusts and any flammable gas (e.g. hydrogen) shall be provided in order to prevent hazards caused by fire or explosion. Explosion protection measures from EN 1127-1 shall be taken where applicable.

To prevent dust explosions, the grinding machines shall be provided for example with systems for

a) wet grinding,

b) dry grinding with wet precipitation by means of instantaneous moistening, or

c) dry grinding with wet precipitation by means of a wet-type cyclone.

For requirements, see Annex G.

5.8 Specific requirements resulting from neglect of ergonomic principles hazards

a) Machines shall be designed in accordance with the ergonomic principles in

   ISO 12100:2010, 6.2.6, 6.2.8 and 6.3.5.6;

   ISO 6385;

   ISO 15534-1;

   ISO 15534-2.

b) The requirements for the positioning of the main control panel are the following:

   1) The main control panel for starting, operational stop, mode selection, and hold-to-run control (if applicable) for the machine, shall be located at the operator's position(s). Control displays and/or actuators shall be protected against swarf and grinding debris and be in accordance with ISO 9355-1, ISO 9355-2, ISO 9355-3, and IEC 60204-1:2009, Clause 10, and shall be protected against unintentional operation, e.g. by collar push button.

   2) No mode selection switch or start control that initiates MSO 1 shall be provided at any other point on the machine than the main control panel. A separate start switch may be provided at a position deviating from the main control panel, if the operator thus has a better view of the hazard zone. If more than one start switch are provided, the control system shall be designed in such a way that the use of one of them precludes the use of the others.

   3) Controls for operating the machine in MSO 2 may be provided remote from the main operating console, e.g. on a pendant. Alternatively, they may be provided at separate consoles outside the hazard zone.

   4) When multiple controls are provided for machine movements in MSO 2, only one shall be operational at any one time.

c) The requirements for unhealthy posture or excessive efforts (repetitive strain) include the design of machines in accordance with ergonomic principles so as to avoid excessive effort, unhealthy posture, or fatigue during use and in particular the following:

   1) Workpieces, tooling and accessories shall be easy to move. Lifting equipment can be required for parts over 10 kg in weight (see EN 1005-1, EN 1005-2, EN 1005-3, EN 1005-4).

   2) Where handling equipment, hoists, or lifting devices are required, provision shall be made for their installation and operation (e.g. by making work zone access possible through the top of the machine when guards are open).

   3) Where parts are manually loaded, their fixtures, e.g. tool holders, shall be positioned to prevent excessive reaching into the machine (see EN 1005-1, EN 1005-2, and EN 1005-3, EN 1005-4).

   4) Control devices to operate clamping or gripping devices (e.g. drawbars, chucks) shall be positioned to avoid excessive reaching while supporting the weight of the tool or workpiece. (e.g. application of foot controls). See EN 894-3:2000, Clause 4.

5) Movable guards shall be power operated where use of them will lead to repeated excessive effort (see also ISO 12100:2010, 6.2.2.2).

d) For consideration of hand-arm or foot-leg anatomy, the positioning of control devices and points for observation or service such as those for filling and draining of tanks shall be chosen to satisfy ergonomic principles (see EN 614-1, EN 614-2, EN 894-1, EN 894-2, EN 894-3; EN 894-4, EN 1005-1, EN 1005-2, EN 1005-3, EN 1005-4; ISO 13855).

e) When designing machinery, lighting intensity, direction, glare, etc. shall be taken into account. When necessary, integral lighting shall be provided. Especially the following items shall be taken into account:

1) the required lighting intensity depends on the grinding operation to be performed. It shall be at least 300 lx in the area to be observed and its immediate vicinity;

2) glare, reflections and shadows, e.g. from workpiece or machine parts, shall be avoided as far as possible;

3) the lighting source shall be positioned to minimize its contamination during machining.

f) Design, location, and identification of manual controls and input devices (e.g. keyboards, keypads, push buttons) shall be in accordance with ISO 9355-1, ISO 9355-2, and ISO 9355-3.

g) For design or location of visual display units, screen displayed information shall be clear and unambiguous. Reflections and glare shall be minimized [see EN 894-1, EN 894-2, EN 894-4, and ISO 9241 (all parts)].

5.9 Specific requirements resulting from unexpected start-up, over-run, or over-speed hazards

a) For the purposes of this International Standard, the condition in IEC 60204-1:2009, 9.2.5.2, is achieved by the interlocking arrangements required in 5.2.3.2 a).

b) The requirements for failure/disorder of the control system are the following:

1) Control systems shall be designed in accordance with IEC 60204-1, ISO 4413 and ISO 4414 and IEC 62061, or ISO 13849-1. Unexpected machine movements (e.g. wheel and work holding spindle rotation, axis movement, grinding tool release from the spindle) shall be prevented (see ISO 14118).

2) Where access is provided to programmable functions for alterations, it shall be lockable to prevent unauthorised access to program data or programmable functions. This can be achieved by the use of a password or a key switch.

3) Safety-related software shall be protected against unauthorised reconfiguration. In particular, it shall not be possible for the user to suspend the operation of safety function (including interlocked guards) by means of sequences inserted in or called up by the part program.

c) The requirements for starting are the following:

1) For requirements concerning safety functions for start and restart function, see 5.12 b) 14) and 19).

2) Where multiple hold-to-run control device locations are provided (e.g. main control station, hand-held pendant), only one shall be functional at a time.

3) The closure of the movable interlocked guards shall not result in the restart of moving machine parts. If power operated guards are provided, see 5.2.3.2 b).

4) Unexpected start-up of hazardous movements, e.g. of wheel and work holding spindles, axes, or work holding devices, shall be prevented in accordance with ISO 14118:2000, Clause 6, when the movable guards are open or in MSO 0.

5) Any control device for manual spindle start shall be designed to prevent an unintentional operation, e.g. mechanical double action device, flush-button, or shrouded push button.

d) The following requirements for the monitoring of reduced speed for spindle and axes shall apply to all modes of safe operation.

1) The reduced spindle and axis speeds depend on the mode of safe operation and shall be monitored accordingly. This also includes the speeds of work holding devices and wheel spindles.

2) If one of the reduced spindle or axis speeds is exceeded, a category 1 stop, in accordance with IEC 60204-1:2009, 9.2.2, shall be initiated automatically.

The grinding wheel spindle shall not be stopped in a manner which can cause slipping, loosening or breakage of the abrasive product in the tool holding device.

3) For requirements concerning safety functions for the monitoring of the reduced speed of workpiece and tool spindles and axes, see 5.12 b) 5) and 6).

e) The requirements for axes movements are the following:

1) Axis movements may be achieved by manual actuation or by power driving:

i) direction of axis movement shall be consistent with the direction of the control device according to the requirements in ISO 447;

ii) unexpected start-up of power operated axis movement shall be prevented (see ISO 14118:2000, Clause 6);

iii) unexpected hazardous movement of vertical or slant axes under gravity shall be prevented (e.g. by weight balance or a redundant brake system).

2) For requirements concerning safety functions for starting of axes movements or unintended descent of vertical or slant axes, see 5.12 b) 15) and 13).

f) The requirements for stopping are the following:

1) Machine movements shall be stopped by stop functions in accordance with IEC 60204-1:2009, 9.2.2.

2) Where persons are exposed to hazards by unexpected start of machine movements, only the stop functions “Safe stop” or “Safe operational stop” shall be used. In case of “Operational stop”, it shall not be possible to open the movable guards.

3) For requirements for safety functions, see 5.12.b) 11) and 12).

g) For restoration of energy supply after an interruption, the control system design shall ensure that automatic restart is prevented and re-actuation of the start control is always required to initiate power operated movement (see ISO 14118).

h) For isolation and energy dissipation:

1) See ISO 12100:2010, 6.2.10 and 6.3.5.4 and ISO 14118:2000, Clause 5.

2) Means shall be provided for the isolation of energy supply (see ISO 4413:2010, 5.1.5, ISO 4414:2010, 5.1.6, and IEC 60204-1:2009, 5.3). For the dissipation of stored energy, see ISO 14118:2000, 5.3.

3) The device for disconnecting electrical supply shall be in accordance with IEC 60204-1:2009, 5.3.

4) When the machine has its own hydraulic pump and/or pneumatic compressor, the electrical isolation of the machine shall also cut the electricity to the motor of the pump and/or compressor. When hydraulic or pneumatic energy is provided from outside the machine, the machine shall have a reliable manually operated and lockable supply disconnecting device

(shut-off valve) meeting the requirements of ISO 14118, Clause 5. Where energy dissipation is not possible automatically as the result of the isolation (see ISO 14118:2000, 5.3.1.3), means for dumping of residual pressure shall be provided. These means may include a valve but not the disconnection of pipes.

i) Pneumatic systems shall be in accordance with ISO 4414.

j) Hydraulic systems shall be in accordance with ISO 4413.

k) The requirements for external influences on the electrical/electronic equipment (electromagnetic compatibility) are the following:

1) Immunity – electronic control systems shall be designed and installed so as to be protected from electromagnetic interference and stable when exposed to electrical system operation or failure in accordance with IEC 61000-6-2.

2) Emission – electrical/electronic design shall apply technical information and physical measures to limit electromagnetic emissions in accordance with IEC 61000-6-4.

NOTE EN 50370–1 and EN 50370–2 are also applicable.

5.10 Specific requirements resulting from variation in the rotational speed hazards

On grinding machines with devices for speed variation of the wheel spindle, the following measures/devices for minimizing the risk of exceeding the maximum operating speed of the clamped abrasive product shall be provided alternatively depending on the driving mode of the wheel spindle:

a) Starting devices which will start the wheel spindle with the lowest adjustable speed only.

b) For pole-changing drives, a switch interlock is required, preventing the direct starting of the higher speed step.

c) On grinding machines where the rotational speed is calculated from the programmed cutting speed and the actual abrasive product diameter, either the control shall recognize an abrasive product change or there shall be a clearly visible warning of the necessary data input in case of an abrasive product change. The data input shall have to be confirmed by the operator.

d) On grinding machines where abrasive products with different outside diameters can be operated, there shall be a clearly visible warning of the maximum rotational speed for the different diameters. The selected speed shall be clearly visible (e.g. control knob with speed scale).

e) Indication of the selected rotational speed or peripheral speed; the indicated values shall be identical to the selected values.

For requirements concerning the safety function monitoring of the reduced wheel and work holding spindle speed, see 5.12 b) 5).

5.11 Specific requirements resulting from failure of the power supply hazards

The requirements for failure of power supply are the following:

a) inadequate pressure or voltage shall be detected and the machine shall be stopped;

b) interruption or a failure of the power supply shall not result in a hazardous loss of workpiece holding or tool clamping (e.g. by means of under voltage and/or under pressure device);

c) restoration of the energy supply shall not result in the machine automatically restarting (see ISO 14118 and ISO 12100:2010, 6.2.11.4);

d) interruption or failure of the power supply shall not result in hazardous movement of vertical or slant axes under gravity (e.g. redundant brake system). For requirements concerning the safety control function to prevent unintended descent of a vertical or slant axis, see 5.12 b) 13);

e) systems shall be designed so that a line rupture in any circuit (e.g. broken wire, pipe or hose) will not result in the loss of a safety function (see IEC 60204-1, ISO 4413, and ISO 4414);

f) means shall be provided for the isolation of energy supply (see ISO 4413:2010, 5.3.2.2 and 5.4.7.2.1 and IEC 60204-1:2009, 5.3). For the dissipation of stored energy, see ISO 14118:2000, 5.3.

5.12 Specific requirements resulting from failure of the control circuit hazards

a) Regarding safety-related hardware and software, for the purposes of this International Standard, safety-related parts of a control system includes the entire system from the initial actuator (control device) or position detector to the point of input to the final actuator or element, e.g. motor. Safety functions of control systems shall be implemented using safety-related parts designed, constructed, and applied in accordance with ISO 13849-1. In general, when activated, the input device to the safety function shall initiate a category 0 or 1 stop of the hazardous movements, in accordance with IEC 60204-1:2009, 9.2.2, and shall prevent unexpected start-up.

b) Safety functions shall meet the requirements for the performance level of ISO 13849-1 as given in this subclause. Annex J exemplarily shows possibilities for realization of the required performance level for the monitoring of the reduced spindle speed of the wheel spindle.

NOTE 1 Risk reduction can be achieved by the application of different protective measures, i.e. safety-related parts of the control system and other protective means, e.g. mechanical means; see ISO 13849-1:2006, Figure 2.

NOTE 2 For risk reduction by other technical means independent from the control system, e.g. mechanical guards, the starting point in the risk diagram for the determination of the PL_r for the intended safety function can be positioned at the point after implementation of this measure; see ISO 13849-1:2006, A.1.

Table 3 — Correlation of safety function and performance level

Safety function	Required performance level, PL_r
1) Interlocking device associated with a movable guard in the following areas, electro-sensitive protective equipment (ESPE), or other safety equipment applied to	
i) work zone;	d category 3
zone only for maintenance;	c
ii) transmissions, drive mechanisms	
with access more than once per hour	d
with access less than or equal to once per hour	c
iii) tool changer, tool magazine;	d
iv) handling device for workpiece loading/unloading	
with access more than once per hour	d
with access less than or equal to once per hour	c
v) pallet changer	
with access more than once per hour	d
with access less than or equal to once per hour	c
vi) access to pits, gates in perimeter fencing	
with access more than once per hour	d
with access less than or equal to once per hour	c
2) Hold-to run control	
as a combination of hold-to run control and enabling device	d
for axis reduced speed monitoring when it is not done in accordance with 5.12 b) 6),	d
for axis reduced speed monitoring when it is done in accordance with 5.12 b) 6)	c
3) Control system with electronic handwheel	
as a combination of control system with electronic handwheel and enabling device	d
for axis reduced speed monitoring when it is not done in accordance with 5.12 b) 6),	d
for axis reduced speed monitoring when it is done in accordance with 5.12 b) 6)	c
4) Enabling device	d
5) Spindles reduced speed monitoring	d category 3
6) Axis reduced speed monitoring for axes if the feed control of the axis movement is effected by means of a hold-to-run device with PL = d of 5.12 b) 2) or	d
by an electronic hand wheel with PL = d of 5.12 b) 3)	
7) Control system of power operated tool clamping and work holding	
for machines which do not require movable guards	c
for machines with movable guards when machining is effected with movable guards open, e.g. machines with MSO 3	c
For modes of safe operation with closed movable guards	b
8) Emergency stop	c

Table 3 *(continued)*

Safety function	Required performance level, PL_r
9) Prevention of crushing hazard at power operated guards/doors with edge protection by e.g. pressure-sensitive protective devices (PSPD)	d
10) Mode of safe operation selection function	c
11) Safe operational stop (stop category 2 in accordance with IEC 61800-5-2:2007)	d
12) Safe stop (stop category 1 in accordance with IEC 61800-5-2:2007)	d
Safe stop (stop category 0 in accordance with IEC 61800-5-2:2007)	c
13) Control function to prevent unintended descent of vertical or slant axis	
if hazard avoidance is difficult	d
if a hazardous descent of vertical or slant axis exists, if a realistic chance of avoiding an accident or significantly reducing its effect is given	c
14) Start and restart function (see 5.9 c))	
for electronic control systems	d
for electromechanical control systems	c
NOTE Start and restart functions are not safety related if they are avoided by other means, e.g. door interlocking, enabling device.	
15) Start of axis movement (see 5.9 e))	
for electronic control systems	d
for electromechanical control systems	c
NOTE Start and restart functions are not safety related if they are avoided by other means, e.g. door interlocking, enabling device.	
16) Prevention of unintended actuation of the CO_2 extinguishing system	
— for accessible machines	c
— for inaccessible machines	b
17) Technical link between fire alarm or automatic fire extinguishing system with the machine control system	b
18) Monitoring of metalworking fluid supply and oil mist extraction when using flammable metalworking fluid	b
19) Prevention of unexpected start of metalworking fluid supply more than or equal to 5 bar	c
Prevention of unexpected start of metalworking fluid supply with use of low pressure metal working fluid system, i.e. less than 5 bar	b

c) Emergency stop

1) Emergency stop functions shall be category 1 or 0 (determined by the risk assessment) in accordance with IEC 60204-1:2009, 9.2.5.4.2. Additionally, they should be in compliance with ISO 12100:2010, 6.3.5.2 and ISO 13850;

2) Emergency stop functions shall be initiated by (an) emergency stop device(s) which shall be in accordance with IEC 60204-1:2009, 10.7 and ISO 13850. An emergency stop device shall be provided at each operator's position including the following:

i) each position, where hazardous movements can be initiated;

ii) at the main control panel;

iii) at any portable control panel (if provided);

iv) at the tool magazine;

v) at workpiece loading and unloading stations.

5.13 Specific requirements resulting from ejected fluids or objects hazards

5.13.1 General requirements

Grinding machines where, besides hazards caused by abrasive product fragments (see 5.13.2), hazards caused by the ejection of workpieces, parts of the workpieces, machine parts, dust, or metalworking fluids are likely to occur shall be provided with fixed and/or movable guards retaining these parts and substances in the work zone. The guards shall be designed, constructed, and located taking into consideration the expected stress. They shall comply with the general requirements of ISO 14120.

The guards to prevent ejection of parts can also serve to contain abrasive product fragments in accordance with 5.13.2 and/or to prevent access to the work zone when they are suitably designed, constructed, and located.

5.13.2 Guards to prevent ejection in the event of abrasive product breakage

5.13.2.1 Abrasive product guards

Grinding machines shall be equipped with abrasive product guards able to contain the fragments effectively in the event of an abrasive product breakage. The wall thicknesses of these guards shall be specified in relation to the type of material used for the guard and the maximum peripheral speed and the mass of the abrasive products.

The guard shall enclose the abrasive product to the greatest extent practicable.

Where parts of the abrasive product guard are connected to each other by welding or other means, the connection shall be strong enough to ensure that parts will not separate when subjected to the impact of fragments.

For requirements for abrasive product guards, see A.3.1 to A.3.3.

The abrasive product guards shall be attached to the grinding machines so that they will not loosen or move in an uncontrolled way in the case of an abrasive product breakage.

For requirements for the attachment of the abrasive product guards, see A.4.

Abrasive product guards and their fixing components shall be rated for the abrasive product with the largest dimensions applicable on the machine at intended use and the maximum rotational speed of the wheel spindle. The highest possible speed in case of failure of the wheel spindle drive shall be considered as the maximum speed.

An abrasive product guard is not required on grinding machines where abrasive products are used with D ≤ 1 000 mm and a peripheral speed of $v \leq 16$ m/s.

In circumstances/situations where an abrasive product guard cannot be provided, a guard enclosing the work zone or other measures leading to the required protection shall be provided. The guard enclosing the work zone shall comply with the requirements of A.3.5.2.2 in relation to the wall thickness and material.

Where rotating dressing tools generate the same hazards as rotating abrasive products, relevant protective measures for these tools shall also be provided.

5.13.2.2 Work zone enclosures

Grinding machines on which abrasive products with a safety factor $S_{br} \leq 1{,}75$ (see EN 12413) [see Formula (1)] or with peripheral speeds $v > 50$ m/s are operated shall be equipped with a work zone

enclosure, retaining the fragments including those ejected from the aperture of the abrasive product guard in the machining area (totally enclosed working area).

$$S_{\mathrm{br}} = \left(\frac{v_{\mathrm{br}}}{v_{\mathrm{s}}} \right)^2 \quad (1)$$

where

S_{br} is the safety factor against bursting due to centrifugal force;

v_{br} is the bursting speed, the peripheral speed at which the abrasive product breaks due to centrifugal force;

v_{s} is the maximum operating speed, maximum permissible peripheral speed of a rotating abrasive product.

Work zone enclosure provision can include the following:

a) fixed and movable guards in accordance with A.3.5;

b) an abrasive product guard, additionally equipped with an internal guard which closes the aperture of the abrasive product guard in the event of an abrasive product breakage (see A.3.1.4).

Work zone enclosure is not required:

c) For manually guided swing frame grinding machines and swing frame cutting-off machines with a peripheral speed of the abrasive product of $v \leq 80$ m/s, see Table 1, No. 1.4.

d) For manually and mechanically guided cutting-off machines with a peripheral speed of the abrasive product of $v < 100$ m/s and a diameter of the cutting-off wheel $D \leq 406$ mm, see Table 1, Nos. 1.3 and 1.5.

Abrasive product guards and work zone enclosures shall be rated for the abrasive product with the largest dimensions applicable on the machine at intended use and the maximum rotational speed of the wheel spindle. The highest possible speed in case of failure of the wheel spindle drive shall be considered as the maximum speed.

NOTE By speed monitoring related to different defined areas of the diameter of the grinding tool, a reduction of the wall thickness of guards (abrasive product guard and work zone enclosure) can be achieved, according to Annex A.

5.13.3 Devices protecting against ejection of workpieces and workpiece parts

5.13.3.1 General

Grinding machines shall be so designed that an ejection of workpieces and/or workpiece parts is prevented. If this is not possible, suitable guards with retaining capacity shall be provided which have to be dimensioned in relation to the energy of these parts.

5.13.3.2 Surface grinding machines

Surface grinding machines (see Table 1, Nos. 1.10 and 1.11) shall be additionally equipped with a containing guard for ejected workpieces located at the border of the work zone in the direction of rotation of the abrasive product. The translational energy of the ejected workpieces shall be determined from the weight of the workpiece and the maximum peripheral speed of the abrasive product. The required dimensions of the containing guard can then be determined by means of the calculation

formulae in A.4.3 for the different materials of the protective device. E_{trans} in the formulae corresponds to the determined energy of the ejected workpiece.

NOTE For surface grinding machines, the maximum workpiece mass to be ejected may be assumed to be m = 0,5 kg.

5.14 Specific requirements resulting from loss of stability hazards

Machines and related equipment shall be designed so that they are stable under the specified conditions of their use. The requirements in ISO 12100:2010, 6.2.6 and 6.3.2.6 shall be met.

5.15 Specific requirements resulting from slips, trips and fall of persons hazards

a) Places of work and means of access on machines (such as stairs, integral ladders, platforms, and walkways) shall be designed to minimize the likelihood of slips, trips, and falls by the provision of hand holds, foot holds, and where necessary slip resistant surfaces. Requirements in ISO 14122-1, ISO 14122-2 and ISO 14122-3 and ISO 14122-4 shall be met.

b) To avoid contamination of floors, where a metalworking fluid supply system is provided, it shall be designed to prevent splash, spray, and mist outside the machine enclosure. Information for use shall draw attention to the importance of preventing fluid spillage onto the surrounding area and thus creating a slipping hazard.

6 Verification of the safety requirements and/or protective measures

Table 4 indicates the methods by which the safety requirements and/or measures described in Clause 5 shall be verified, together with a reference to the corresponding (sub)clauses in this International Standard.

Table 4 — Verification methods

(Sub) clause	Safety requirements and/or protective measures	Verification method				
		Visual inspection	Functional test	Measurement	Calculation	Documentation
5.1	General requirements					
5.1.2	Required characteristics for guards for all grinding machine groups	X	X	X		X
5.2	Specific requirements resulting from mechanical hazards					
5.2.1	Group 1 machines, manually controlled grinding machines without power operated axes and without numerical control	X	X	X		X
5.2.2	Group 2 machines, manually controlled grinding machines with power operated axes and limited numerically controlled capability, if applicable	X	X	X		X
5.2.3	Group 3 machines, numerically controlled grinding machines					
5.2.3.1	Access to the work zone	X	X			X
5.2.3.2	Specific requirements for guards	X	X	X		X

Table 4 *(continued)*

(Sub) clause	Safety requirements and/or protective measures	Verification method				
		Visual inspection	Functional test	Measurement	Calculation	Documentation
5.2.3.3	Other specific requirements	X	X	X	X	X
5.2.4	Tool holding devices	X	X	X	X	X
5.2.5	Workpiece holding					
5.2.5.2	Workpiece rests	X		X		X
5.2.5.3	Power operated clamping devices	X	X	X		X
5.2.6	Vertical and slant axes under gravity	X	X			X
5.2.7	Modes of machine operation					
5.2.7.1	Mode selection	X	X			X
5.2.7.2	MSO 0: Manual mode	X	X	X		X
5.2.7.3	MSO 1: Automatic mode	X	X			X
5.2.7.4	MSO 2: Setting mode	X	X	X		X
5.2.7.5	MSO 3: Optional special mode for manual intervention under restricted operating conditions	X	X	X		X
5.2.7.6	MSO service	X	X	X		X
5.2.8	Optional or additional equipment for grinding machines					
5.2.8.1	Handling devices for workpiece loading/unloading	X	X			X
5.2.8.2	Machines equipped with a tailstock and/or quill	X	X	X		X
5.2.8.3	Externally accessible tool magazine, tool transfer and tool changing mechanism	X	X	X		X
5.3	Specific requirements resulting from electrical hazards	X	X	X		X
5.4	Specific requirements resulting from noise hazards	X	X	X		X
5.5	Specific requirements resulting from vibration hazards	X	X	X		X
5.6	Specific requirements resulting from radiation hazards	X	X	X		X
5.7	Specific requirements resulting from materials or substances hazards					
5.7.1	General	X	X	X		X
5.7.2	Equipment for the use of metalworking fluids					
5.7.2.1	General	X	X	X		X
5.7.2.2	Measures for the protection against contact or inhalation	X	X	X		X

Table 4 *(continued)*

(Sub) clause	Safety requirements and/or protective measures	Verification method				
		Visual inspection	Functional test	Measurement	Calculation	Documentation
5.7.2.3	Biological and microbiological hazards (viral or bacterial)	X	X			X
5.7.3	Measures against fire and explosion hazards					
5.7.3.1	Flammable metalworking fluids	X	X	X		X
5.7.3.2	Flammable and explosive dusts	X	X			X
5.8	Specific requirements resulting from neglect of ergonomic principles hazards	X	X	X		X
5.9	Specific requirements resulting from unexpected start-up, over-run or over-speed hazards	X	X			X
5.10	Specific requirements resulting from variation in the rotational speed hazards	X	X			X
5.11	Specific requirements resulting from failure of the power supply hazards	X	X			X
5.12	Specific requirements resulting from failure of the control circuit hazards	X	X		X	X
5.13	Specific requirements resulting from ejected fluids or objects hazards					
5.13.1	General requirements	X	X			X
5.13.2	Guards to prevent ejection in the event of abrasive product breakage					
5.13.2.1	Abrasive product guards	X	X	X	X	X
5.13.2.2	Work zone enclosures	X	X	X	X	X
5.13.3	Devices protecting against ejection of workpieces and workpiece parts	X	X	X	X	X
5.14	Specific requirements resulting from loss of stability hazards	X	X			X
5.15	Specific requirements resulting from slips, trips and fall of persons hazards	X	X			X
7	Information for use					
7.1	Marking	X				X
7.2	Instruction for use	X				X

7 Information for use

NOTE See ISO 12100:2010, 6.4.

7.1 Marking

Grinding machines shall bear markings in accordance with ISO 12100:2010, 6.4.4. At least the following markings shall be provided:

a) For its unambiguous identification

   1) the business name and full address of the manufacturer and, where applicable, his authorized representative;

   2) the designation of the machine, series or type of machine;

   3) the serial number, if any;

   4) the year of construction, that is the year in which the manufacturing process was completed.

b) In order to indicate its compliance with mandatory requirements (e.g. the CE marking);

c) For its safe use

   1) the direction of rotation of the wheel spindle;

   2) the maximum permissible speed or speed range of the wheel spindle(s) in rotations per minute or the peripheral speed in m/s;

   3) the maximum permissible dimensions of the abrasive product;

   4) the weight of the machine;

   5) supply data for electrical, hydraulic and pneumatic systems;

   6) the maximum permissible work holding spindle speed in rotations per minute;

   7) guards, protective devices and other parts of the machine, which are not permanently attached, shall be marked with identification data;

   8) a machine presenting a fire or explosion risk shall be provided with an appropriate marking, if

      i) the extinguishing agent provided with the machine presents hazards, and

      ii) the machine is exclusively intended for the machining of special materials (e.g. light metals) and the machining of other (e.g. spark forming) materials can generate hazards.

7.2 Instruction for use

7.2.1 General

An instruction handbook in accordance with ISO 12100:2010, 6.4.5, completed with the specific information for the stated grinding machine, shall be provided with the machine.

The instructions for use shall provide all necessary information regarding transport, assembly/disassembly, operation, setting, maintenance, cleaning, etc. to train or qualify the operators sufficiently in intended and safe use of the machine.

The instruction handbook shall specify that it is essential that operators be adequately trained in the safe use, adjustment, and operation of the machine. At least the following information shall be given:

a) Specifications on machining processes and modes of safe operation for which the grinding machine is suited. If the machine provides MSO 2 and/or MSO 3 and/or MSO service, the details of the intended use of these modes have to be defined.

   1) Information on the foreseeable misuse shall be given.

   2) Information on possible residual risks, e.g. for

      i) any provided mode of safe operation (e.g. MSO 0, MSO 1, MSO 2, MSO 3, or MSO service),

      ii) noise (see 7.2.6),

      iii) vibration on manually guided machines (see 7.2.7), and

      iv) touching the abrasive product when the tool is guided by hand.

   3) Information on the necessary qualification of operators, in particular if the machine enables MSO 0, MSO 2, MSO 3, and/or MSO service, which, for example can comprise experiences in

      i) adjusting and clamping of workpieces and devices,

      ii) setting, operating and monitoring of grinding machines,

      iii) selection and use of abrasive products,

      iv) mounting and dressing of the abrasive product,

      v) data input for the machining of workpieces and optimization of the machining process,

      vi) special hazards and safety requirements, and

      vii) use of personal protective equipment.

NOTE In MSO 3 and in MSO service, additional skills can be necessary (see 7.2.9).

In addition to the general information required according to ISO 12100:2010, the following information shall be given in the instruction for use:

b) A requirement that the safeguards shall be in place and functional before starting the machine for each mode of safe operation;

c) Any necessary information for safe installation (e.g. floor conditions, services, vibration dampening);

   This includes information on the location for machines for the use with flammable metalworking fluids, which are equipped with pressure relief devices, and information on the location of the wet precipitator for machines for the working of materials during which flammable and explosive dusts are generated.

d) A requirement for maintenance, including a list of those devices which shall be inspected or tested, including frequency and methods of the tests;

e) The frequency of visual inspections that are necessary to ensure the protective function of vision panels and transparent screens

   1) Inspection methods and a description of defects which make the transparent screen unsuitable for continued use or indicate that replacement is required. This information can include descriptions of unacceptable transparent screen condition, e.g. plastic deformation (bulges, dents) due to previous impact events, cracks, damage to edge sealing, coolant penetration (effect of ageing) into composite, evidence of degrading such as tarnishing/discolouration, other damage to protective layers. Polycarbonate transparent screens are dangerous as soon

as they are tarnished or discoloured and that they have to be replaced with new transparent screens before that happens.

2) The manufacturer's recommendations for the replacement of transparent screens shall take into consideration the material properties of the respective transparent screen. For the special case of polycarbonate, see A.3.6.

3) The recommended methods of cleaning of transparent screens without causing damage and, where appropriate, the selection and use of suitable cleaning agents.

4) A requirement that when changing transparent screens the assembly instructions of the machine manufacturer shall be followed.

f) Recommendations on handling and lifting heavy parts/tools or workpieces including the location of lifting points of exchangeable components, e.g. tools, parts, clamping devices;

g) Recommendations on the use of a calibration laser (where applicable, see IEC 60825-1);

h) Recommendations on selection, preparation, application, and maintenance of lubricants for the braking and transmission systems;

i) Recommendations on selection, preparation, application, and maintenance of metalworking fluids and precautions against their degradation and the information to follow the recommendations of the manufacturer of the metalworking fluid;

j) Recommendations on the measures to prevent spattering, spraying, or ejection of metalworking fluids, e.g. cleanliness of collecting gutters, and on avoidance of spillage of fluids in the environment of the machine;

k) Recommendation on the reduction of the fire and explosion risk for the selection of flammable metalworking fluids. This includes e.g. information on viscosity and flash point and on the reduction of aerosol and vapour formation through selection of low-emission metalworking fluids (see Annex I);

l) Recommendation to use additional precautions when working with flammable metalworking fluids

This includes information on

1) escape of hot gases at door gaps and openings of the machine,

2) hot surfaces and parts possibly live after a fire,

3) backfire hazards during opening/restart of the machine directly after a fire, and

4) prevention of ingress of foreign substances such as

i) machine cleaning and conditioning products,

ii) workpiece cleaning products and solvents, and

iii) foreign oils etc.,

in order to maintain the safety-related properties of the metalworking fluid with regard to fire and explosion hazards over its lifetime.

m) Recommendations on additional precaution measures, if flammable or explosive dusts are formed during machining (see as well 7.2.9, second paragraph);

n) Instructions to enable the release of trapped persons;

o) Recommendations concerning the use of personal protective equipment (e.g. hand, ear and eye protection);

p) Instructions for connection of an extraction system where the machining process generates hazardous substances (e.g. dusts and mists);

q) Warning on hazards and precaution measures at workplaces and accesses to machines (e.g. ladders, working platforms, runways) presenting slip, trip, or fall hazards.

7.2.2 Tooling

a) Information on selection and handling of abrasive products and clamping flanges, on the appropriate mounting and clamping of abrasive products, on ring test and speed test, on the use of intermediate layers and spacers, on the starting of new abrasive products, on truing and dressing, see Annex D. The information on the selection of abrasive products should include advice on the checking of the applicability of low-noise abrasive products, if applicable.

b) Information on the maximum permissible mass and the spatial envelope of the abrasive products on grinding machines supplied with automatic loading devices.

c) Information on the selection of abrasive product guards for different types and dimensions of abrasive products.

d) Information on the safeguards and protective measures, e.g. personal protective equipment, which might be necessary during manual clearing of chip spaces of the abrasive product.

7.2.3 Workpiece holding

The following information about workpiece holding and workpiece holding devices shall be supplied.

a) **For workpiece holding devices supplied with the machine:** Information about how the workpiece holding device shall be used and maintained (e.g. maintenance and lubrication schedule).

b) **For workpiece holding devices that can be used**: Recommendations on the clamping of workpieces, including information on collets or chucks that can be used with the machine together with the recommendation for use/maintenance from the workpiece holding device manufacturer.

c) **For replacement/changing the workpiece holding device:** Information to enable workpiece holding devices (e.g. chucks, faceplates or collets), to be selected, fitted, and/or changed, for instance data relevant to that part of the clamping device/machine interface belonging to the machine or unbalance requirements for chucks and faceplates.

d) **For workpiece holding device modifications**:

   1) Information shall be given that modification of workpiece holding devices supplied with or fitted to the machine may reduce or alter the maximum permissible spindle speed or the efficiency of these devices.

   2) Information shall be given that workpiece holding devices shall only be modified within the limits given by the grinding machine manufacturer and in accordance with the clamping device manufacturer's recommendations.

   3) Information shall be given on equipment added to or substituted for workpiece holding devices (e.g. jaws) which would reduce the maximum permissible speed of those devices. Such equipment shall be clearly marked with the reduced maximum permissible speed in rotations per minute.

7.2.4 Machine functions accessible from the NC panel

The instructions for use shall describe the correct selection and use of machine functions accessible from the NC panel, e.g. tool corrections, mode access, and mode changes.

7.2.5 Restart

Information shall be provided on restart procedures. In particular, after exchange of the abrasive product, the machine setter shall enter the maximum speed of the abrasive product. After each program change, the operator shall enter and/or validate the maximum operating speed and both speeds shall be validated by the operator.

The operator shall enter and or validate the maximum operating speed for the particular workpiece and the maximum speed of the workpiece.

7.2.6 Noise

The following information on airborne noise emissions of the machine shall be provided:

a) the A-weighted emission sound pressure level at workstations, where this exceeds 70 dB(A); where this level does not exceed 70 dB(A), this fact shall be indicated;

b) the peak C-weighted instantaneous emission sound pressure level at workstations, where this exceeds 63 Pa (130 dB in relation to 20 μPa);

c) the A-weighted sound power level emitted by the machinery, where the A-weighted emission sound pressure level at workstations exceeds 80 dB(A).

These values shall be either those actually measured for the machinery in question or those established on the basis of measurements taken for technically comparable machinery which is representative of the machinery to be produced.

In the case of very large machinery, instead of the A-weighted sound power level, the A-weighted emission sound pressure levels at specified positions around the machinery may be indicated.

Whenever sound emission values are indicated, the uncertainties surrounding these values shall be specified. The operating conditions of the machinery during measurement and the measuring methods used shall be described.

The position and value of the maximum sound pressure shall be indicated.

The declaration shall be accompanied by a statement of the measuring method used and the operating conditions applied during the test and values for uncertainty *K,* using dual number form of declaration defined in accordance with ISO 4871:

— K = 4 dB when using ISO 3746 or ISO 11202 (grade 3);

— K = 2,5 dB when using ISO 3744 or ISO 11204 (grade 2).

EXAMPLE For a sound power level L_{WA} = 83 dB(A) (measured value), uncertainty K = 4 dB(A) for measurements made in accordance with ISO 3746.

NOTE Another example can be found in ISO 230-5:2000, Annex E.

If the accuracy of the declared emission values is to be verified, measurements shall be made using the same method and the same operating conditions as those declared.

The noise declaration shall be accompanied by the following statement:

> “The figures quoted are emission levels and are not necessarily safe working levels. Whilst there is a correlation between the emission and exposure levels, this cannot be used reliably to determine whether or not further precautions are required. Factors that influence the actual level of exposure of the workforce include the characteristics of the workroom and the other sources of noise, i.e. the number of machines and other adjacent processes and the length of time for which an operator is exposed to the noise. Also, the permissible exposure level can vary from country to country. This information, however, will enable the user of the machine to make a better evaluation of the hazard and risk.”

7.2.7 Vibration

In case the upper parts of the body are exposed to vibrations, e.g. manually guided grinding machines, the instruction handbook shall contain the following information concerning vibrations transmitted by the machinery.

— The total vibration value to which the upper parts of the body are exposed if the determined value is above 2,5 m/s^2.

— If the total vibration value to which the upper parts of the body are exposed does not exceed 2,5 m/s^2, this shall be indicated.

— Measuring uncertainties shall be advised.

The instruction handbook shall also give the following:

a) information on technical measures for vibration reduction;

b) information on personal protective equipment, if appropriate;

c) the operating conditions of the machinery during vibration measurement;

d) the transducer positions during measurement;

e) the vibration measurement methods used;

f) the criteria on which the vibration declaration is made (e.g. EN 12096).

7.2.8 Ancillary handling devices

If ancillary handling devices are to be integrated on the machine, the ancillary handling device manufacturer/supplier shall provide information necessary to enable the machine manufacturer/supplier to install these devices for use.

7.2.9 Residual risks to be addressed by the machinery user

Information shall be provided to warn that guards provided or supplied with the machine in accordance with Annex A are intended to minimize the risks of ejection and not to eliminate them completely. Also, the minimum distance of the operator to vision panels shall be provided.

Advice shall be provided that processing substances such as aluminium or magnesium can cause additional hazards, e.g. fire and explosion or noxious dust.

Instructions shall be provided on the necessary checks following the exchange of components removal of equipment or change of software where these can affect safety functions.

Information shall be provided to indicate that machining unbalanced workpieces can create an ejection hazard and that the way to minimize the risk is to counter balance or machine at reduced speeds.

Information shall be provided on machining processes and modes of safe operation for which the grinding machine is suited.

Information on possible residual risks, e.g. through mechanical hazards in setting mode and manual machining mode, shall be provided.

If the machine provides MSO 3 according to 5.2.7.5,

— the details of the intended use and safety measures shall be documented by the machine manufacturer/supplier, and

— the manufacturer/supplier of the machine shall specify the required skill level for the operator(s) to operate MSO 3.

If the machine provides MSO service in accordance with 5.2.7.6, the manufacturer of the machine shall specify

— the details of the application(s) of MSO service,

— the required skills and the skill level for the operator(s) to operate MSO service, and

— all tools and work holding devices (if applicable) to be removed.

Information shall be provided on the main parameters the user has to consider to lower the noise emission level, e.g.

a) tool selection,

b) workpiece/tool clamping, and

c) maintenance.

7.2.10 Installation instructions for the grinding machine

Information about the required foundation and how to install and support the machine shall be provided. Above all, the safe handling of heavy parts of large machines shall be described.

7.2.11 Cleaning instruction for the machine

Information about the foreseen cleaning procedures shall be provided. All utilities (e.g. handholds, footholds and/or slip resistant surfaces) shall be described and the way to reach all sides/parts of the machine shall be explained.

Annex A
(normative)

Abrasive product guards, work zone enclosures, and their combinations

A.1 General

The following requirements apply to abrasive product guards, work zone enclosures, and their combinations intended for the use of bonded abrasive products and superabrasive products.

A.2 Abbreviated terms and symbols

A_S	shearing cross section of a fixing element	[mm^2]
A_T	reduced shaft cross section of a reduced bolt	[mm^2]
D	diameter of the shearing area	[mm]
E	total energy of the rotating abrasive product	[J]
E_{trans}	translational energy of a fragment	[J]
E'_{trans}	translational energy of a fragment for the calculation of the fixing elements of the abrasive product guard	[J]
E_{rot}	rotational energy of a fragment	[J]
ΔE	loss of energy during the impact	[J]
F	force of impact	[N]
F_m	average shearing force	[N]
F_{max}	maximum shearing force	[N]
k	coefficient of impact	[–]
l_s	reduced shaft length of a reduced bolt	[mm]
m	mass of abrasive product	[kg]
m_{Br}	mass of a fragment	[kg]
m_{SH}	mass of abrasive product guard	[kg]
n	number of clamping elements	[–]
Q	ratio of bore diameter and outside diameter of abrasive product	[–]
R_{eH}	yield point	[N/mm^2]
R_m	tensile strength	[N/mm^2]
$R_{p0,2}$	0,2 % proof stress	[N/mm^2]

s	displacement	[mm]
s_w	shearing distance	[mm]
v	peripheral speed of an abrasive product	[m/s]
v_{max}	maximum possible peripheral speed of an abrasive product in case of failure of wheel spindle drive	[m/s]
v_s	maximum operating speed of an abrasive product	[m/s]
W_D	energy absorption capacity of a reduced bolt at tensile impact	[J]
W_i	energy absorption capacity of the ith clamping element	[J]
W_s	energy absorption capacity of a shearing element at shearing impact	[J]
z	number of abrasive product fragments	[–]
α	half angle of fragments	[°]
$\widehat{\alpha}$	half angle of fragments (radian measure)	[–]
ε_B	elongation of break	[%]
ε_R	elongation at rupture	[%]
E	elastic modulus	[N/mm^2]
σ_m	arithmetic mean from yield point R_{eh} or 0,2 % proof stress $R_{p0,2}$ and tensile strength R_m	[N/mm^2]
ρ	density	[g/cm^3]
τ_s	shearing strength	[N/mm^2]

A.3 Requirements for abrasive product guards and work zone enclosures

A.3.1 Shapes of abrasive product guards and angles of aperture

A.3.1.1 General

Abrasive product guards shall safely retain fragments in the case of an abrasive product breakage. Generally, the abrasive product is totally enclosed by the abrasive product guard. The angle of aperture is different for the various types of grinding machines and shall give access only to that part of the abrasive product necessary for the machining process.

A.3.1.2 Abrasive product guards for peripheral grinding

Abrasive product guards on grinding machines for peripheral grinding, cutting-off, profile grinding, in accordance with Table 1, Nos. 1.3, 1.5, 1.10, 1.13, 1.14 shall enclose the abrasive product with a maximum angle of aperture of 150° (see Figures A.1 and A.2).

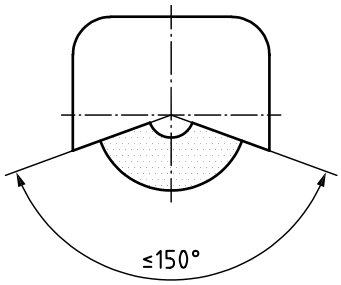


Figure A.1

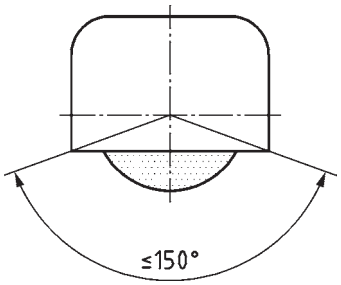
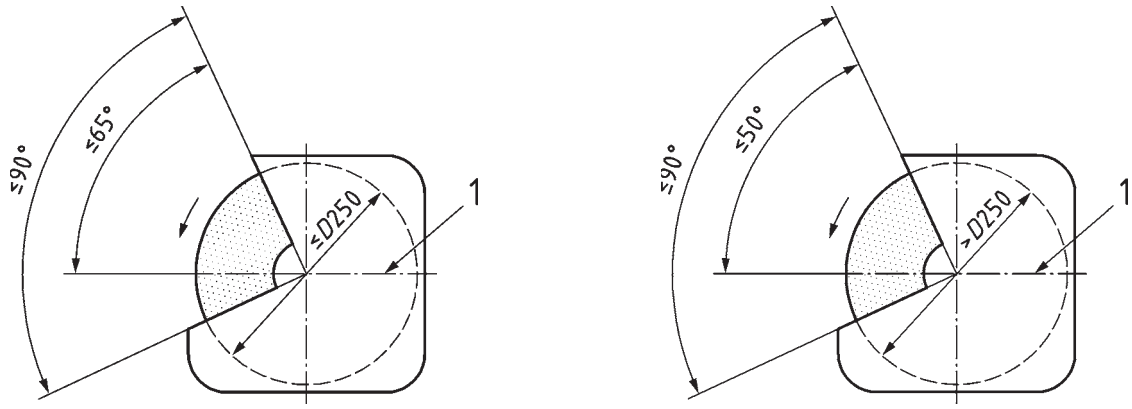


Figure A.2

A.3.1.3 Abrasive product guards for peripheral grinding with peripheral speeds of $v \leq 50$ m/s on bench and pedestal grinding machines (see Table 1, No. 1.1)

The angle of aperture of the abrasive product guard shall not exceed 90°, the angle above the x-axis shall not exceed 65° for abrasive products with an outside diameter $D \leq 250$ mm, and shall not exceed 50° for abrasive products with an outside diameter $D > 250$ mm (see Figure A.3).



a) outside diameter $D \leq 250$ mm **b) outside diameter $D > 250$ mm**

Key

1 x-axis

Figure A.3

Abrasive product guards for abrasive products with an outside diameter $D \geq 125$ mm shall be designed so that for peripheral wear the width of the gap between the abrasive product and the abrasive product guard can be adjusted to ≤5 mm. For examples, see Figures A.4 to A.9.

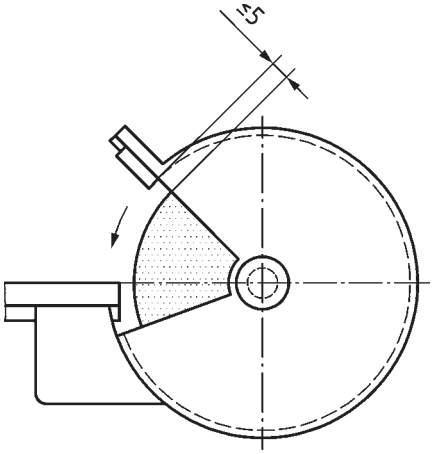


Figure A.4

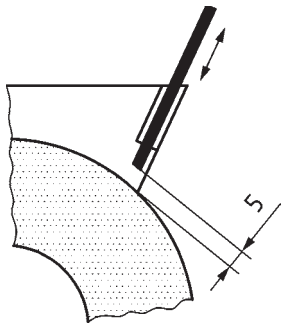


Figure A.5

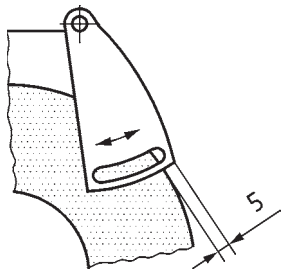


Figure A.6

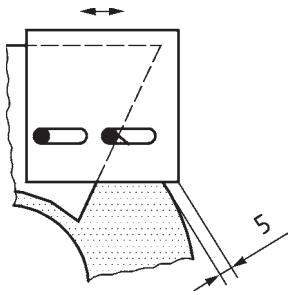


Figure A.7

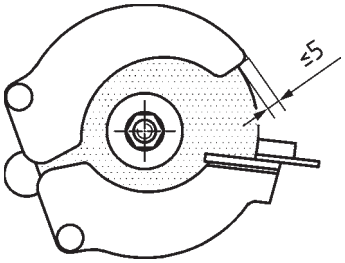


Figure A.8

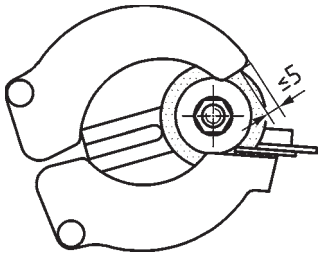


Figure A.9

The lateral distance between abrasive product and abrasive product guard shall not exceed 10 mm (see Figure A.10).

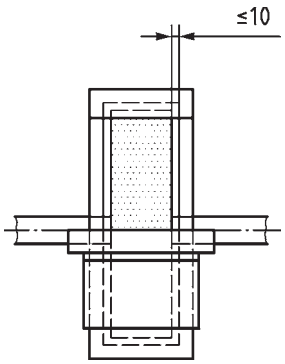
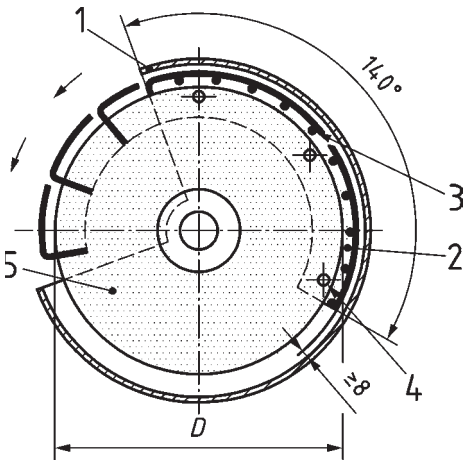


Figure A.10

A.3.1.4 Abrasive product guards for peripheral grinding with peripheral speeds of v > 50 m/s on bench and pedestal grinding machines (see Table 1, No. 1.1)

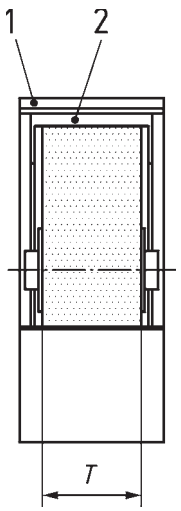
Bench and pedestal grinding machines for abrasive products with v_s > 50 m/s shall be equipped with an abrasive product guard and an internal guard. The internal guard closes the abrasive product guard aperture in the event of a grinding abrasive product breakage (see Figures A.11 and A.12).



Key

1 abrasive product guard
2 internal guard
3 carrier peg
4 fastening screw
5 grinding abrasive product

Figure A.11



Key

1 abrasive product guard
2 internal guard

Figure A.12

Requirements and design of the internal guard:

U-shaped profiles adapted to the internal contour of the circular guard. The centring angle shall be 140°. As a function of the outside diameter of the abrasive product, the following widths of the wheel (*T)* shall be observed:

NOTE Experiments have shown that a safe operation is only ensured if the following diameter/width ratios are complied with:

$D \geq 500$ mm $T \geq 60$ mm

$D \geq 600$ mm $T \geq 50$ mm

$D \geq 762$ mm $T \geq 40$ mm

On the inside of the rotating part of the U-shaped profile, carrier pegs are to be provided.

The internal guard shall be attached to the side parts of the guard by means of fixing elements. The fixing elements shall have a low breaking elongation, e.g. M5 10.9.

The wall thickness of the internal guard shall at least be 3 mm, but 5 mm at maximum, material 1 to 3 in accordance with Table A.7.

The internal guard shall be arranged so that the distance between the inner side of the guard and the outer side of the internal guard is a minimum of 8 mm (see Figure A.11).

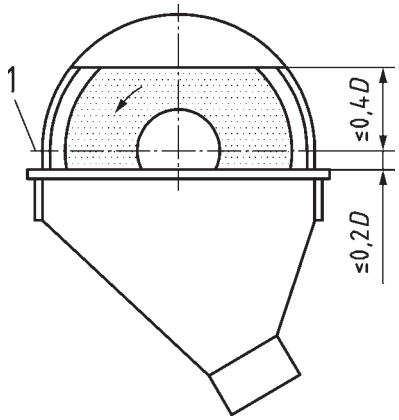
A.3.1.5 Abrasive product guards for side grinding on bench and pedestal grinding machines (see Table 1, No. 1.2)

Abrasive product guards for side grinding abrasive products with or without recess shall be designed so that the aperture

— above the x-axis does not exceed 0,4 *D*, and

— below the x-axis does not exceed 0,2 *D*.

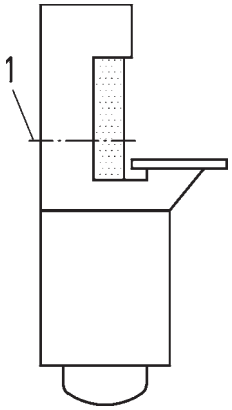
See Figures A.13 and A.14.



Key

1 x-axis

Figure A.13



Key

1 x-axis

Figure A.14

For abrasive product guards for abrasive products with an outside diameter $D \leq 200$ mm, the front enclosure above the x-axis is not necessary if the peripheral part extends outside the periphery of the abrasive product by at least 5 mm (see Figures A.15 and A.16).

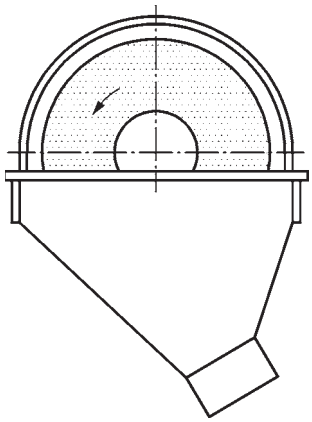


Figure A.15

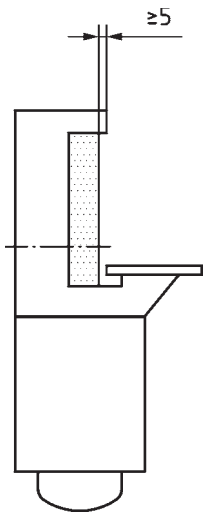


Figure A.16

A.3.1.6 Abrasive product guards for internal cylindrical grinding machines (see Table 1, No. 1.9)

For examples for automatically acting devices for protection against contact with the abrasive product, e.g. during workpiece removal, see Figures A.17 to A.20.

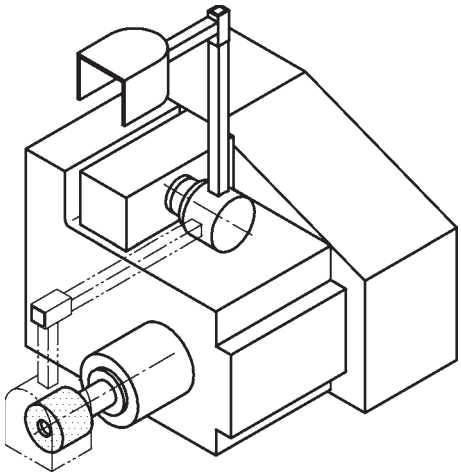


Figure A.17

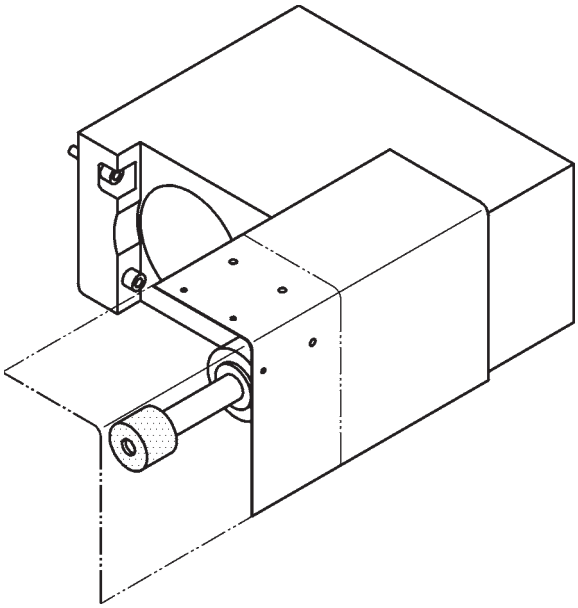


Figure A.18

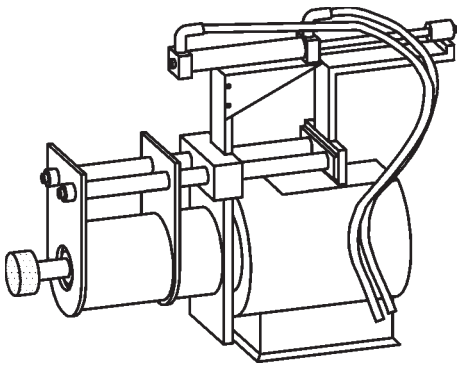


Figure A.19

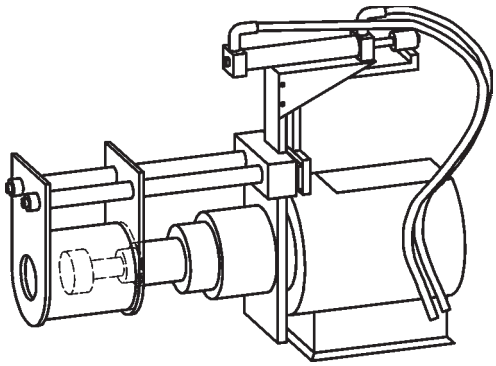
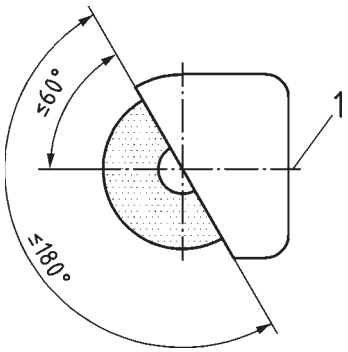


Figure A.20

During the machining process, ejection of abrasive product fragments shall be prevented by work zone enclosures in accordance with 5.13.2.2.

A.3.1.7 Abrasive product guards for external cylindrical grinding machines (see Table 1, No. 1.7 and No. 1.8)

The total angle of aperture of the abrasive product guard shall not exceed 180°, the opening above the x-axis shall not exceed 60° (see Figure A.21).



Key

1 x-axis

Figure A.21

Abrasive product guards for abrasive products with outside diameter $D \geq 250$ mm shall be designed so that for peripheral wear of the abrasive products the gap between the abrasive product periphery and the abrasive product guard can be adjusted to ≤5 mm (see Figures A.5 to A.7).

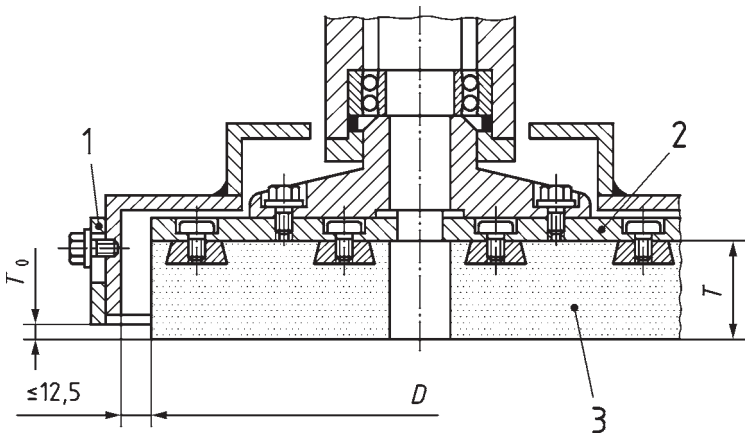
A.3.1.8 Abrasive product guards for side grinding on surface grinding machines (see Table 1, No. 1.11)

For moving adjustable abrasive product guards (also with adjustable protective band) where the axial movement of the abrasive product carrier is transmitted, the clearance between the peripheral face of the abrasive product and the inside of the abrasive product guard shall be a maximum of 12,5 mm and the open (unprotected) width of the abrasive product T_0, projecting from the moving adjustable abrasive product guard (adjustable protective band) shall be

$T_0 \leq 0{,}3\ T$ for $T \leq 50$ mm

$T_0 \geq 0{,}2\ T$ for $T > 50$ mm

See Figure A.22.



Key

1 adjustable guard band
2 interchangeable steel disc
3 grinding abrasive product

Figure A.22

A.3.1.9 Abrasive product guards for side grinding on double spindle grinding machines (see Table 1, No. 1.12)

Abrasive product guards for double spindle grinding machines shall totally enclose the work zone except for openings for loading and unloading of workpieces (see Figures A.23 and A.24).

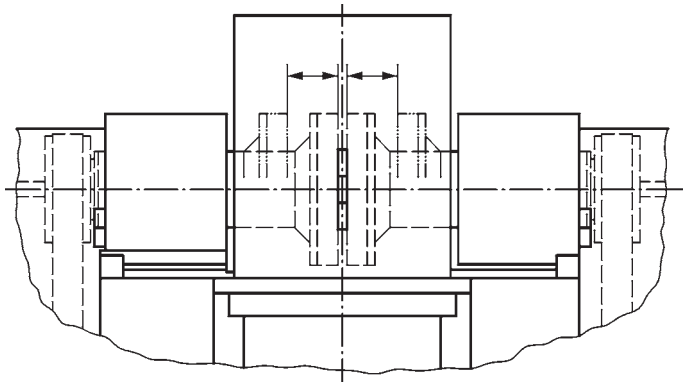


Figure A.23

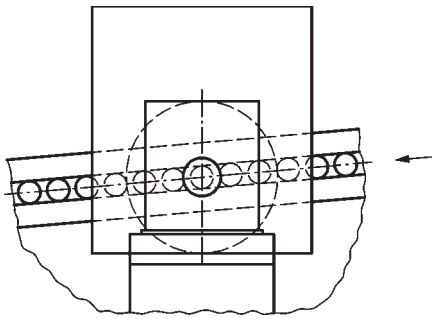


Figure A.24

A.3.1.10 Abrasive product guards for tool grinding machines (see Table 1, No. 1.6)

The type of abrasive product guard used shall depend on the shape and position of the abrasive product and the operation to be carried out.

The angle of aperture of the abrasive product guard shall not exceed 180°. The abrasive product guard shall cover the whole width of the abrasive product (see Figures A.25 and A.26).

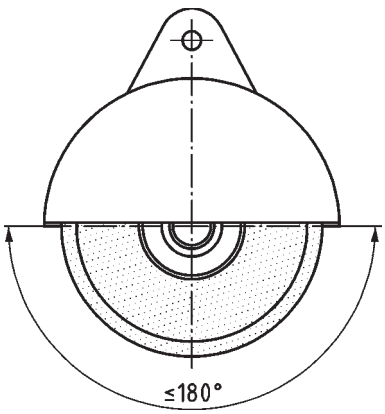


Figure A.25

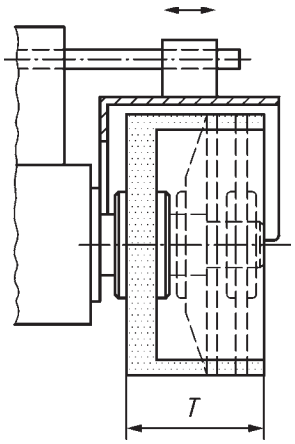


Figure A.26

A.3.1.11 Abrasive product guards for swing frame grinding machines and swing frame cutting-off machines (see Table 1, No. 1.4)

The angle of aperture of the abrasive product guard shall not exceed 160° (see Figure A.27).

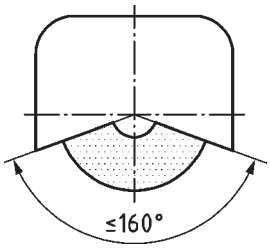


Figure A.27

A.3.2 Wall thicknesses and material

A.3.2.1 General

Abrasive product guards shall be of the dimensions given in Tables A.1 to A.6 depending on the material used (see Table A.7). The wall thicknesses specified for the abrasive product dimensions and peripheral speeds given in the tables shall be considered as minimum values.

If the grinding machine is intended for the use of different types of abrasive products or for different peripheral speeds, the abrasive product guard dimensions shall always be based on the case where the highest energy of fragments (for calculation, see A.4 2) is expected.

For gang mounted wheels, the dimensioning of the wall thickness of the guard shall consider the abrasive product with the highest energy of fragments (for calculation, see A.4.2). The dimensioning of the guard shall be based on 150 % of this energy value for bonded abrasive products, or 100 % for superabrasive products.

The principles for the determination of the wall thicknesses are described in A.4. For abrasive product dimensions and peripheral speeds not listed in the tables, the wall thickness can be determined by means of the procedure described. The wall thickness should be at least 1,5 mm.

For abrasive product dimensions and/or peripheral speeds where higher fragment energies can be expected than those taken as basis for the values in the tables, the designer shall specify the dimensions individually. In this case, the design shall provide for the use of either additional energy absorbing elements within the abrasive product guard or thicker product guards.

A.3.2.2 Wall thicknesses

See Tables A.1 to A.6.

Table A.1 — Wall thicknesses for steel abrasive product guards for bonded abrasive products, except for cutting-off wheels

Dimensions in millimetres

Material[a]	Peripheral speed[d] v_{max} m/s	Width of abrasive product T	Outside diameter of abrasive product D																			
			125		200		315		406		508		610		762		914		1 067		1 250	
			Minimum wall thicknesses[b,c]																			
			t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s
		25	1,5	1,5	2,5	2	3	2,5	4	3	4,5	3,5	5	4	6	4,5	7	5	8	6	8,5	6,5
		50	2	1,5	3	2	4	3	5	3,5	6	4,5	6,5	5	8	6	9	6,5	10	7,5	11	8,5
		100	2,5	2	4	3	5	4	6,5	5	7,5	5,5	8,5	6,5	10	7,5	11,5	8,5	13	10	14,5	11
		160	3	2,5	4,5	3,5	6	4,5	7,5	5,5	9	6,5	10	7,5	12	9	13,5	10,5	15	11,5	17	13
1		200	3,5	2,5	5	3,5	7	5	8	6	9,5	7	11	8	13	10	15	11	16,5	12,5	18,5	14
2	32	250	4	3	5,5	4	7,5	5,5	9	6,5	10,5	8	12	9	14	10,5	16	12	18	13,5		
3		315					8	6	10	7	11,5	8,5	13	10	15,5	11,5	17,5	13				
8		400							10,5	8	12,5	9,5	14	10,5	17	12,5	19	14,5				
		500									13,5	10	15,5	11,5	18	13,5						
		600									15,5	12	16,5	12,5	19,5	14,5						
		25	2,0	1,5	2,5	2	3,5	3	4,5	3,5	5,5	4	6	4,5	7	5,5	8	6	9	7	10,5	7,5
		50	2,5	2	3,5	2,5	5	3,5	6	4,5	7	5	8	6	9	7	10,5	8	12	9	13	10
		100	3	2,5	4,5	3,5	6	4,5	7,5	5,5	9	6,5	10	7,5	12	9	13,5	10	15	11,5	17	13
		160	3,5	3	5	4	7	5,5	9	6,5	10,5	8	12	9	14	10,5	16	12	18	13,5	20,5	15
1		200	4	3	5,5	4,5	8	6	9,5	7	11,5	8,5	13	10	15,5	11,5	17,5	13	19,5	14,5	22	16,5
2	40	250	4,5	3,5	6	5	8,5	6,5	10,5	8	12,5	9	14	10,5	16,5	12,5	19	14,5	21,5	16		
3		315					9,5	7	11,5	8,5	13,5	10	15,5	11,5	18	13,5	20,5	15,5				
8		400							12,5	9,5	14,5	11	17	12,5	20	15	22,5	17				
		500										16	12	18	13,5	21,5	16					

[a] Designation of material (see Table A.7).

[b] t_p Wall thickness peripheral part.

t_s Wall thickness side part.

[c] Determination of the wall thicknesses (see A.4.3).

[d] Highest possible peripheral speed of the abrasive product taking account of a fault of the wheel spindle drive (monitored speed).

Table A.1 *(continued)*

Material[a]	Peripheral speed[d] v_{max} m/s	Width of abrasive product T	Outside diameter of abrasive product D																			
			125		200		315		406		508		610		762		914		1 067		1 250	
			Minimum wall thicknesses[b,c]																			
			t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s
		600										17	12,5	19,5	14,5	23	17					

a Designation of material (see Table A.7).

b t_p Wall thickness peripheral part.

t_s Wall thickness side part.

c Determination of the wall thicknesses (see A.4.3).

d Highest possible peripheral speed of the abrasive product taking account of a fault of the wheel spindle drive (monitored speed).

Table A.1 — *(continued)*

Material[a]	Peripheral speed[d] v_{max} m/s	Wicth of abrasive product T	Outside diameter of abrasive product D																	
			125		200		315		406		508		610		762		914		1 067		1 250	
			Minimum wall thicknesses[b,c]																	
			t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s
	50	25	2,5	1,5	3	2,5	4,5	3,0	5	3,5	6	4,5	7	5,5	8,5	6,5	9,5	7	11	8	12	9
		50	3	2	4	3	5,5	4,5	7	5	8	6	9	7	11	8	12,5	9,5	14	10,5	15,5	11,5
		100	3,5	2,5	5	4	7,5	5,5	9	6,5	10,5	8	12	9	14	10,5	16	12	18	13,5	20	15
		160	4,5	3	6	4,5	8,5	6,5	10,5	8	12,5	9	14	10,5	16,5	12,5	19	14	21,5	16	24	18
1		200	5	3,5	6,5	5	9,5	7	11,5	8,5	13,5	10	15,5	11,5	18	13,5	20,5	15,5	23	17,5	26	19,5
2		250	5	4	7	5,5	10	7,5	12	9	14,5	11	16,5	12,5	19,5	14,5	22,5	17	25	19		
3		315					11	8,5	13,5	10	15,5	12	18	13,5	21,5	16	24,5	18,5				
8		400							14,5	11	17	13	20	15	23,5	17,5	26,5	20				
		500									18,5	14	21,5	16	25,5	19						
		600									20	15	23	17	27	20						
	63	25	2,5	2	3,5	3	5	4	6	4,5	7,5	5,5	8,5	6,5	10	7,5	11,5	8,5	12,5	9,5	14,5	11
		50	3,5	2,5	5	3,5	6,5	5	8	6	9,5	7	11	8	13	9,5	14,5	11	16,5	12,5	18,5	14
		100	4,5	3,5	6	4,5	8,5	6,5	10,5	8	12	9	14	10,5	16,5	12,5	19	14	21	16	24	18
		160	5	4	7	5,5	10	7,5	12,5	9	14,5	11	16,5	12,5	19,5	15	22,5	17	25	19	28,5	21,5
1		200	5,5	4,5	8	6	11	8,5	13,5	10	16	12	18	13,5	21,5	16	24,5	18,5	27,5	20,5		
2		250	6	4,5	8,5	6,5	12	9	14,5	11	17	13	20	15	23	17,5	26,5	20				
3		315					13	10	16	12	18,5	14	21,5	16	25,5	19						
8		400							17,5	13	20,5	15	23,5	17,5	27,5	20,5						
		500									22	16,5	25,5	19								

[a] Designation of material (see Table A.7).

[b] t_p Wall thickness peripheral part.

t_s Wall thickness side part.

[c] Determination of the wall thicknesses (see A.4.3).

[d] Highest possible peripheral speed of the abrasive product taking account of a fault of the wheel spindle drive (monitored speed).

Table A.1 *(continued)*

Material[a]	Peripheral speed[d] v_{max} m/s	Wicth of abrasive product T	Outside diameter of abrasive product D																	
			125		200		315		406		508		610		762		914		1 067		1 250	
			Minimum wall thicknesses[b,c]																	
			t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s
		600									23,5	17,5	27	20								

[a] Designation of material (see Table A.7).

[b] t_p Wall thickness peripheral part.

t_s Wall thickness side part.

[c] Determination of the wall thicknesses (see A.4.3).

[d] Highest possible peripheral speed of the abrasive product taking account of a fault of the wheel spindle drive (monitored speed).

Table A.1 — *(continued)*

Material[a]	Peripheral speed[d] v_{max} m/s	Width of abrasive product T	Outside diameter of abrasive product D																	
			125		200		315		406		508		610		762		914		1 067		1 250	
			Minimum wall thicknesses[b,c]																	
			t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s
1 2 3 8	80	25	3	2,5	4,5	3,5	6	4,5	7,5	5,5	9	6,5	10	7,5	12	9	13,5	10	15	11,5	17	13
		50	4	3	5,5	4	8	6	9,5	7	11,5	8,5	13	10	15,5	11,5	17,5	13	19,5	14,5	22	16,5
		100	5	4	7,5	5,5	10,5	7,5	12,5	9	14,5	11	17	12,5	20	15	22,5	17	25,5	19	28,5	21,5
		160	6	4,5	8,5	6,5	12	9	14,5	11	17,5	13	20	15,5	23,5	17,5	27	20				
		200	6,5	5	9,5	7	13	10	16	12	19	14	21,5	16,5	25,5	18						
		250	7,5	5,5	10,5	7,5	14,5	11	17,5	13	20,5	15	23,5	17,5	28	21						
		315					15,5	11,5	19	14	22	16,5	25,5	19								
		400							20,5	15,5	24,5	18	28	21								
1 2 3 8	100	25	3,5	3	5	4	7,5	5,5	9	6,5	10,5	7,5	12	9	14	10,5	16	12	18	13,5	20	15
		50	4,5	3,5	6,5	5	9,5	7	11,5	8,5	13,5	10	15,5	11,5	18	13,5	20,5	15,5	23	17,5	26	19,5
		100	6	4,5	8,5	6,5	12	9	14,5	11	17	13	20	15	23,5	17,5	26,5	20				
		160	7,5	5,5	10,5	7,5	14,5	11	17,5	13	20,5	15	23,5	17,5	27,5	21						
		200	8	6	11	8,5	15,5	11,5	19	14	22	16,5	25,5	19								
1 2 3 8	125	25	4,5	3	6	4,5	8,5	6,5	10,5	7,5	12	9	14	10,5	16,5	12,5	19	14				
		50	5,5	4	8	6	11	8	13,5	10	15,5	12	18	13,5	21,5	16	24,5	18,5				
		100	7	5,5	10	7,5	14	10,5	17	13	20	15	23,5	17,5	27,5	21						
		160	8,5	6,5	12	9	17	12,5	20,5	15	24	18	27,5	21								

[a] Designation of material (see Table A.7).

[b] t_p Wall thickness peripheral part.

t_s Wall thickness side part.

[c] Determination of the wall thicknesses (see A.4.3).

[d] Highest possible peripheral speed of the abrasive product taking account of a fault of the wheel spindle drive (monitored speed).

Table A.2 — Wall thicknesses for cast steel abrasive product guards for bonded abrasive products, except for cutting-off wheels

Material[a]	Peripheral speed[d] v_{max} m/s	Width of abrasive product T	Outside diameter of abrasive product D																	
			125		200		315		406		508		610		762		914		1 067		1 250	
			Minimum wall thicknesses[b,c]																	
			t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s
4	32	25	2,5	2	3	2,5	4,5	3,5	5,5	4	6,5	5	7,5	5,5	8,5	6,5	10	7,5	11	8,5	12,5	9,5
		50	3	2,5	4	3	6	4,5	7	5	8	6	9,5	7	11	8,5	12,5	9,5	14	10,5	16	12
		100	4	3	5,5	4	7,5	5,5	9	6,5	10,5	8	12	9	14,5	11	16,5	12	18,5	14	20,5	15,5
		160	4,5	3,5	6,5	4,5	9	6,5	10,5	8	12,5	9,5	14,5	11	17	13	19,5	14,5	22	16,5	24,5	18,5
		200	5	3,5	7	5	9,5	7	11,5	8,5	13,5	10	15,5	12	18,5	14	21	16	23,5	18	26,5	20
		250	5,5	4	7,5	6	10,5	8	12,5	9,5	15	11	17	13	20	15	23	17	25,5	19,5		
		315					11,5	8,5	13,5	10,5	16	12	18,5	14	22	16,5	25	19				
		400							15	11	17,5	13	20	15	24	18	27	20,5				
		500									19	14	22	16,5	26	19,5						
		600									20,5	15,5	23,5	17,5	27,5	21						
4	40	25	3	2	4	3	5,5	4	6,5	5	7,5	5,5	8,5	6,5	10	7,5	11,5	8,5	13	10	14,5	11
		50	3,5	2,5	5	3,5	7	5	8	6	9,5	7	11	8,5	13	10	15	11	16,5	12,5	19	14
		100	4,5	3,5	6,5	4,5	9	6,5	10,5	8	12,5	9,5	14,5	11	17	12,5	19	14,5	21,5	16	24,5	18
		160	5	4	7,5	5,5	10,5	8	12,5	9,5	15	11	17	13	20	15	23	17	25,5	19,5	29	21,5
		200	5,5	4,5	8	6	11	8,5	13,5	10	16	12	18,5	14	22	16,5	25	18,5	28	21	31,5	23,5
		250	6	4,5	9	6,5	12	9	14,5	11	17,5	13	20	15	23,5	17,5	27	20	30,5	22,5		
		315					13	10	16	12	19	14	22	16,5	25,5	19,5	29,5	22				
		400							17,5	13	20,5	15,5	24	18	28	21	32	24				
		500									22,5	17	26	19,5	30,5	23						

[a] Designation of material (see Table A.7).

[b] t_p Wall thickness peripheral part.

t_s Wall thickness side part.

[c] Determination of the wall thicknesses (see A.4.3).

[d] Highest possible peripheral speed of the abrasive product taking account of a fault of the wheel spindle drive (monitored speed).

Table A.2 *(continued)*

Material[a]	Peripheral speed[d] v_{max} m/s	Width of abrasive product T	Outside diameter of abrasive product D																	
			125		200		315		406		508		610		762		914		1 067		1 250	
			Minimum wall thicknesses[b,c]																	
			t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s
		600									24	18	27,5	21	32,5	24,5						

a Designation of material (see Table A.7).

b t_p Wall thickness peripheral part.

t_s Wall thickness side part.

c Determination of the wall thicknesses (see A.4.3).

d Highest possible peripheral speed of the abrasive product taking account of a fault of the wheel spindle drive (monitored speed).

Table A.2 — *(continued)*

Dimensions in millimetres

Material[a]	Peripheral speed[d] v_{max} m/s	Width of abrasive product T	Outside diameter of abrasive product D																			
			125		200		315		406		508		610		762		914		1 067		1 250	
			Minimum wall thicknesses[b,c]																			
			t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s
4	50	25	3	2,5	4,5	3,5	6	4,5	7,5	5,5	9	6,5	10	7,5	12	9	13,5	10,5	15,5	11,5	17	13
		50	4	3	6	4	8	6	9,5	7,5	11,5	8,5	13	10	15,5	11,5	17,5	13	20	15	22	16,5
		100	5	4	7,5	5,5	10,5	8	12,5	9,5	14,5	11	17	12,5	20	15	22,5	17	25,5	19	28,5	21,5
		160	6	4,5	9	6,5	12,5	9	15	11	17,5	13	20	15	23,5	18	27	20	30	22,5	34	25,5
		200	6,5	5	9,5	7	13,5	10	16	12	19	14	22	16,5	25,5	19	29	22	33	24,5	37	27,5
		250	7,5	5,5	10,5	8	14,5	11	17,5	13	20,5	15,5	23,5	18	28	21	32	24	36	27		
		315					15,5	12	19	14	22,5	17	25,5	19	30	22,5	34,5	26				
		400							20,5	15,5	24,5	18,5	28	21	33	25	38	25,5				
		500									26,5	20	30,5	23	36	27						
		600									28	21	32,5	24,5	38,5	29						
4	63	25	4	3	5	4	7,5	5,5	9	6,5	10,5	8	12	9	14	10,5	16	12	18	13,5	20,5	15,5
		50	5	4	7	5	9,5	7	11,5	8,5	13,5	10	15,5	11,5	18	13,5	21	15,5	23,5	17,5	26,5	20
		100	6	4,5	9	6,5	12	9	14,5	11	17,5	13	20	15	23,5	17,5	27	20	30	22,5	34	25,5
		160	7,5	5,5	10,5	8	14,5	11	17,5	13	20,5	15,5	24	18	28	21	32	24	36	27		
		200	8	6	11,5	8,5	16	12	19	14,5	22,5	17	26	19,5	30,5	23	35	26	39	29		
		250			12,5	9	17	13	20,5	15,5	24,5	18,5	28	21	33	25	38	28,5				
		315					18,5	14	22,5	17	26,5	20	30,5	23	36	27						
		400							24,5	18,5	29	21,5	33,5	25	39,5	29,5						
		500									31,5	23,5	36	27								

[a] Designation of material (see Table A.7).

[b] t_p Wall thickness peripheral part.

t_s Wall thickness side part.

[c] Determination of the wall thicknesses (see A.4.3).

[d] Highest possible peripheral speed of the abrasive product taking account of a fault of the wheel spindle drive (monitored speed).

Table A.2 *(continued)*

Material[a]	Peripheral speed[d] v_{max} m/s	Width of abrasive product T	Outside diameter of abrasive product D																	
			125		200		315		406		508		610		762		914		1 067		1 250	
			Minimum wall thicknesses[b,c]																	
			t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s
		600									33,5	25	39	29								

a Designation of material (see Table A.7).

b t_p Wall thickness peripheral part.

t_s Wall thickness side part.

c Determination of the wall thicknesses (see A.4.3).

d Highest possible peripheral speed of the abrasive product taking account of a fault of the wheel spindle drive (monitored speed).

Table A.3 — Wall thicknesses for spheroidal graphite cast iron abrasive product guards for bonded abrasive products, except for cutting-off wheels

Dimensions in millimetres

Material[a]	Peripheral speed[d] v_{max} m/s	Width of abrasive product T	Outside diameter of abrasive product D											
			125		200		315		406		508		610	
			Minimum wall thicknesses[b,c]											
			t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s
5	32	25	3,5	3	5	4	7	5,5	8,5	6,5	10	7,5	12	9
		50	4,5	3,5	6,5	5	9	7	11	8,5	13	10	15	11,5
		100	6	4,5	8,5	6,5	12	9	14,5	11	17	13	19,5	14,5
		160	7	5,5	10	7,5	14	10,5	17	13	20	15	23	17,5

[a] Designation of material (see Table A.7).

[b] t_p Wall thickness peripheral part.

t_s Wall thickness side part.

[c] Determination of the wall thicknesses (see A.4.3).

[d] Highest possible peripheral speed of the abrasive product taking account of a fault of the wheel spindle drive (monitored speed).

Table A.4 — Wall thicknesses for aluminium alloy abrasive product guards for bonded abrasive products, except for cutting-off wheels

Dimensions in mm

Material[a]	Peripheral speed[d] v_{max} m/s	Width of abrasive product T	Outside diameter of abrasive product D									
			125		200		315		406		508	
			Minimum wall thicknesses[b,c]									
			t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s
6	40	10	2,5	2	3	2,5	4,5	3,5	5,5	4	6,5	5
		20	3	2,5	4	3	6	4,5	7	5,5	8,5	6,5
		32	3,5	2,5	5	3,5	7	5,5	8,5	6,5	10	7,5
	50	10	3	2	4	3	5,5	4	6,5	5	7,5	6
		20	3,5	2,5	5	3,5	7	5,5	8,5	6,5	10	7,5
		32	4	6	6	4,5	8,5	6,5	10	7,5	12	9
	63	10	3	2,5	4,5	3,5	6,5	5	7,5	6	9	7
		20	4	3	6	4,5	8,5	6,5	10	7,5	12	9
		32	5	3,5	7	5,5	10	7,5	12	9	14	10,5
7	32	10	5	4	7	5,5	10	7,5	12	9	14	11
		20	6,5	5	9	7	13	10	15,5	11,5	18,5	14
		32	8	6	11	8	15,5	11,5	18,5	14	22	16,5
		10	6	4,5	8,5	6,5	12	9	14	11	17	12,5

[a] Designation of material (see Table A.7).

[b] t_p Wall thickness peripheral part.

t_s Wall thickness side part.

[c] Determination of the wall thicknesses (see A.4.3).

[d] Highest possible peripheral speed of the abrasive product taking account of a fault of the wheel spindle drive (monitored speed).

Table A.4 *(continued)*

Material[a]	Peripheral speed[d] v_{max} m/s	Width of abrasive product T	Outside diameter of abrasive product D									
			125		200		315		406		508	
			Minimum wall thicknesses[b,c]									
			t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s
	40	20	7,5	6	11	8	15	11	18,5	14	21,5	16
		32	9	7	13	9,5	18	13,5	22	16	26	19

[a] Designation of material (see Table A.7).

[b] t_p Wall thickness peripheral part.

t_s Wall thickness side part.

[c] Determination of the wall thicknesses (see A.4.3).

[d] Highest possible peripheral speed of the abrasive product taking account of a fault of the wheel spindle drive (monitored speed).

Table A.5 — Wall thicknesses for steel or cast steel abrasive product guards for bonded cutting-off wheels

Dimensions in millimetres

Material[a]	Dimensions of cutting-off wheels																			
	Outside diameter D	150		250		350		500		600		800		1 000		1 250		1 500		1 800	
	Bore diameter H	16		32		32		40		60		60		100		100		127		203,2	
	Width T	3,2		4		4		6		8		10		13		16		16		20	
	Peripheral speed[d] v_{max}	Minimum wall thicknesses[b,c]																			
	m/s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s
1	63	1,5	1,5	2	1,5	3	2	4	3	5,5	4	7	5,5	9,5	7	12	9	13,5	10	17	13
2	80	1,5	1,5	2,5	2	3,5	2,5	5	4	6,5	5	8,5	6,5	11	8,5	14	10,5	16	12	20	15
3 8	100	2	1,5	3	2,5	4	3	6	4,5	7,5	5,5	10	7,5	13,5	10	16,5	12,5	19	14,5	24	18
4	63	2	1,5	3	2,5	4	3	6	4,5	8	5,5	10,5	8	13,5	10	17	13	19,5	15	24,5	18
	80	2,5	2	4	3	5	3,5	7	5,5	9	7	12,5	9,5	16	12	20	15	23	17,5	29	22
	100	3	2	4,5	3,5	5,5	4	8,5	6,5	10,5	8	14,5	11	19	14	24	18	27,5	20,5	34	25,5

[a] Designation of material (see Table A.7).

[b] t_p Wall thickness peripheral part.

t_s Wall thickness side part.

[c] Determination of the wall thicknesses (see A.4.3).

[d] Highest possible peripheral speed of the abrasive product taking account of a fault of the wheel spindle drive (monitored speed).

Table A.6 — Wall thicknesses for steel abrasive product guards for superabrasives with steel or aluminium core

Dimensions in millimetres

Material[a]	Peripheral speed[d] v_{max} m/s	Width of abrasive product T	Outside diameter of abrasive product D													
			150		200		300		400		500		600		750	
			Minimum wall thicknesses[b,c]													
			t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s
1 2 3 8	50	20	1,5	1,5	2	1,5	2	1,5	2,5	2	2,5	2	3	2	3	2,5
		40	2	1,5	2,5	2	3	2	3	2,5	3,5	2,5	3,5	3	4	3
1 2 3 8	63	20	2	1,5	2,5	1,5	2,5	2	3	2	3	2,5	3,5	3	3,5	3
		40	2,5	2	3	2	3,5	2,5	4	3	4	3	4,5	3,5	5	3,5
1 2 3 8	80	20	2,5	2	2,5	2	3	3,5	3,5	2,5	4	3	4	3	4,5	3,5
		40	3	2,5	3,5	2,5	4	3	4,5	3,5	5	3,5	5	4	5,5	4,5
1 2 3 8	100	20	3	2	3	2,5	3,5	3	4	3	4,5	3,5	5	3,5	5	4
		40	3,5	2,5	4	3	4,5	3,5	5,5	4	5,5	4,5	6	4,5	6,5	5
1 2	125	20	3	2,5	3,5	2	4	3	4,5	3,5	5	4	5,5	4	6	4,5

[a] Designation of material (see Table A.7).

[b] t_p Wall thickness peripheral part.

t_s Wall thickness side part.

[c] Determination of the wall thicknesses (see A.4.3).

[d] Highest possible peripheral speed of the abrasive product taking account of a fault of the wheel spindle drive (monitored speed).

Table A.6 *(continued)*

Material[a]	Peripheral speed[d] v_{max} m/s	Width of abrasive product T	Outside diameter of abrasive product D											
			150		200		300		400		500		600		750	
			Minimum wall thicknesses[b,c]											
			t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s	t_p	t_s
3 8		40	4	3	4,5	3,5	5,5	4	6	4,5	6,5	5	7	5,5	7,5	5,5
1 2	140	20	3,5	2,5	4	3	4,5	3,5	5	4	5,5	4,5	6	4,5	6,5	5
3 8		40	4,5	3,5	5	4	6	4,5	6,5	5	7	5,5	8	6	8,5	6,5
1 2	160	20	4	3	4,5	3,5	5	4	5,5	4,5	6	4,5	6,5	5	7	5,5
3 8		40	5	4	5,5	4,5	6,5	5	7,5	5,5	8	6	8,5	6,5	9,5	7
1 2	180	20	4,5	3	5	3,5	5,5	4	6	4,5	7	5	7,5	5,5	8	6
3 8		40	5,5	4	6	4,5	7	5,5	8	6	9	6,5	9,5	7	10,5	7,5
1 2	200	20	4,5	3,5	5	4	6	4,5	7	5	7,5	5,5	8	6	8,5	6,5
3 8		40	6	4,5	6,5	5	8	6	8,5	6,5	9,5	7	10	7,5	11	8,5

a Designation of material (see Table A.7).

b t_p Wall thickness peripheral part.

t_s Wall thickness side part.

c Determination of the wall thicknesses (see A.4.3).

d Highest possible peripheral speed of the abrasive product taking account of a fault of the wheel spindle drive (monitored speed).

Table A.7 — Choice of material

	Material designation		Mechanical strength properties		
		in accordance with ISO	R_m N/mm²	R_{eH} N/mm²	ε_B %
1	Cold-reduced carbon steel sheet of commercial and drawing qualities	3574	270	140	28
2	Cold-reduced steel sheet of structural quality	4997 6316	300	220	18
3	Steels for general engineering purposes	1052	340	215	17
4	Cast carbon steels for general engineering purposes	3755	450	230	22
5	Spheroidal graphite cast iron	1083	400	250	15
6	Wrought aluminium alloys	6361-2	310	260	10
7	Cast aluminium alloys	3522	200	—	3
8	Hot rolled stainless plate	9444	520	205	—
9	Polycarbonate	—	60	E = 2 400 N/mm²	$\varepsilon_R > 80$

A.3.3 Compound abrasive product guards

A.3.3.1 General

If abrasive product guards are joined from individual parts, e.g. by means of welding, screwing, riveting, the components shall be connected so that in case of breakage of the abrasive product, joints will not separate due to the resulting energy.

A.3.3.2 Welded abrasive product guards

A.3.3.2.1 Drawings

The representation of the welding lines in the design drawings shall be in accordance with ISO 2553.

A.3.3.2.2 Preparation

Preparation of the parts for welding shall be in accordance with the drawings supplied. It is particularly important that where full penetration welds are called for, the correct procedures are carried out.

A.3.3.2.3 Personnel

The welder shall have attained approval under the conditions specified in the relevant standard.

— For steel abrasive product guards, a test certificate as per ISO 9606-1 is required.

— For aluminium alloy abrasive product guards, a test certificate as per ISO 9606-2 is required.

A.3.3.2.4 Welding process

The welding process and weld metal shall be selected taking into consideration the parent metal. The welding procedure shall be in accordance with the requirements of ISO 15607 and ISO 3834-1.

A.3.3.2.5 Inspection and testing

The quality of the weld shall be to the standard specified in ISO 5817, Table 1 quality level C (medium).

After welding and post weld treatment, the component shall be examined visually. For abrasive product guards with wall thickness > 20 mm, a non-destructive testing of the weld seams shall be carried out.

NOTE It is not permissible to ignore the first and last 25 mm of the length of butt joint or filler weld since it is expected that some joints will be relatively short and the required standard must be maintained for the complete joint.

A.3.4 Screens for bench and pedestal grinding machines

The minimum dimensions of the transparent part of rectangular, trapezoidal, or round screens of bench and pedestal grinding machines equipped with plain grinding abrasive products are given in Table A.8 and Figure A.28.

These dimensions are given as function of the abrasive product nominal diameter D and for a grinding abrasive product width T limited to 0,15 D.

When T is greater than 0,15 D, $b_{1\ \mathrm{min}}$ shall be raised in proportion to the real value of T. The smaller base b_2 of trapezoidal screens shall be equal to at least 1,5 times the grinding abrasive product width T, with a minimum value of 75 mm.

The minimum dimensions of the transparent part of the screens of bench and pedestal grinding machines equipped with face or cup grinding wheels are identical to those for the screens of these grinding machines equipped with plain grinding wheels; however, the width T of plain grinding wheels should be replaced by the width W of the working part of face grinding wheels.

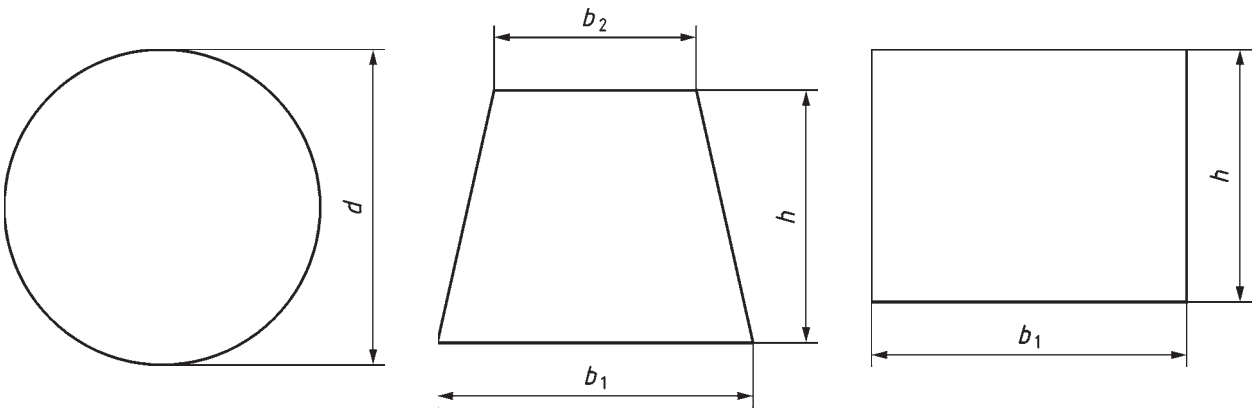


Figure A.28

Table A.8 — Dimensions of the screens

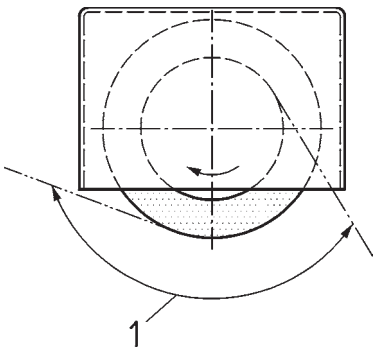
Dimensions in millimetres

Outside diameter of the grinding abrasive product D	$b_{1\,min}$	h	b_2	d
100/200	..75	..60	75	75
200	80	70	80	85
230/250	100	80	80	95
300	125	100	80	115
356	140	110	100	130
406/457	150	115	100	135
508	200	150	100	170
610	200	175	100	182
762	200	175	100	182

A.3.5 Work zone enclosures

A.3.5.1 Spreading area

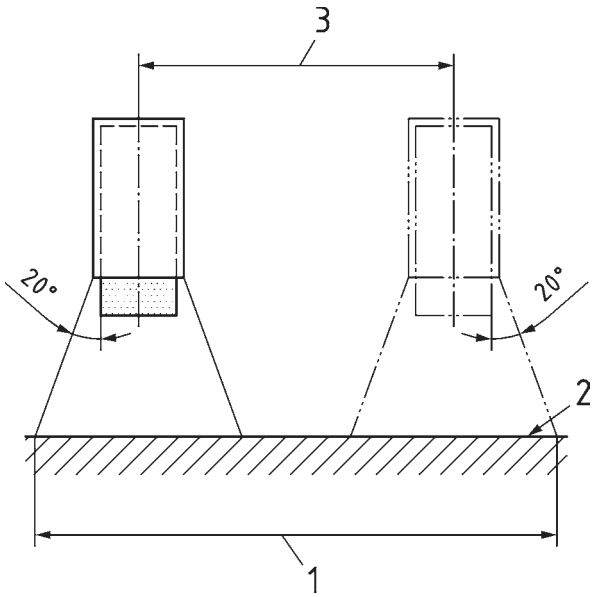
Spreading area is the area of a grinding machine where dispersed fragments from an abrasive product (tool) burst can be foreseen.



Key

1 spreading area

Figure A.29



Key

1 spreading area
2 work zone enclosure
3 travelling distance

Figure A.30

The spreading area corresponds to about the largest width of the abrasive product designated for the grinding machine plus an area arising on both sides from an angle of at least 20° to the free side faces of the abrasive product (see Figure A.30). Free side faces are faces which are not enclosed by the guard or by the flanges.

Traverse and rotating movements of the wheel spindle head shall be taken into account when specifying the spreading area (see Figure A.30).

A.3.5.2 Wall thicknesses and materials

A.3.5.2.1 Wall thicknesses and materials of work zone enclosures on grinding machines with abrasive product guards

Steel sheet

In the spreading area, wall thickness of 0,2 times t_p in accordance with Table A.1, A.5, or A.6, but at least 1,5 mm. Material 1, 2, 3, or 8 of Table A.7.

Polycarbonate

In the spreading area, wall thickness of 0,5 times t_p in accordance with Table A.1, but at least 3 mm. Material 9 of Table A.7.

A.3.5.2.2 Wall thicknesses and materials of work zone enclosures for grinding machines without abrasive product guards

Steel sheet

In the spreading area, wall thicknesses in accordance with Table A.1, A.5, or A.6, the wall thickness outside the spreading area may, however, be 0,2 times t_p in accordance with Table A.1, A.5, or A.6, but shall be not less than 1,5 mm. Materials 1, 2, 3, or 8 of Table A.7.

Polycarbonate

In the spreading area, wall thickness of 2,5 times t_p in accordance with Table A.1, A.5, or A.6, but not less than 3 mm. Outside the spreading area at least 3 mm. Material 9 of Table A.7.

NOTE Extensive investigations at steel sheet and polycarbonate have revealed that for a wall thickness relation of t_{pc} = 2,5 × t_{steel}, approximately equal values result for the impact resistance (t_{pc} = thickness of polycarbonate, t_{steel} = thickness of steel sheet).

A.3.6 Attachment of vision panels in work zone enclosures

Vision panels in work zone enclosures shall be attached to the interior part of the enclosure by clamping or gluing.

In order to guarantee the protective effect of the vision panel, a sufficient coverage of the vision panel with the surrounding steel sheet structure is required. The following minimum values shall be observed:

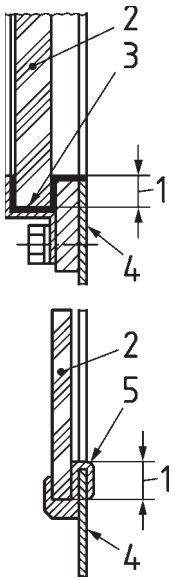
a) grinding machine with abrasive product guard and work zone enclosure, location of the vision panel outside the spreading area (see Figures A.29 and A.30) – minimum coverage 10 mm (see Figure A.31);

b) grinding machine with abrasive product guard and work zone enclosure, location of the vision panel within the spreading area (see Figures A.29 and A.30) – minimum coverage 15 mm, from a size of the vision panel of 500 mm, the minimum coverage shall be 35 mm (see Figure A.31);

c) grinding machine without abrasive product guard but with work zone enclosure, location of the vision panel outside the spreading area (see Figures A.29 and A.30) – minimum coverage 15 mm (see Figure A.31);

d) grinding machine without abrasive product guard but with work zone enclosure, location of the vision panel within the spreading area (see Figures A.29 and A.30) – the manufacturer shall furnish proof of the suitability of the attachment of the vision panel to contain abrasive product fragments. For verification methods, see Annexes B and C.

Machining side **Access side**



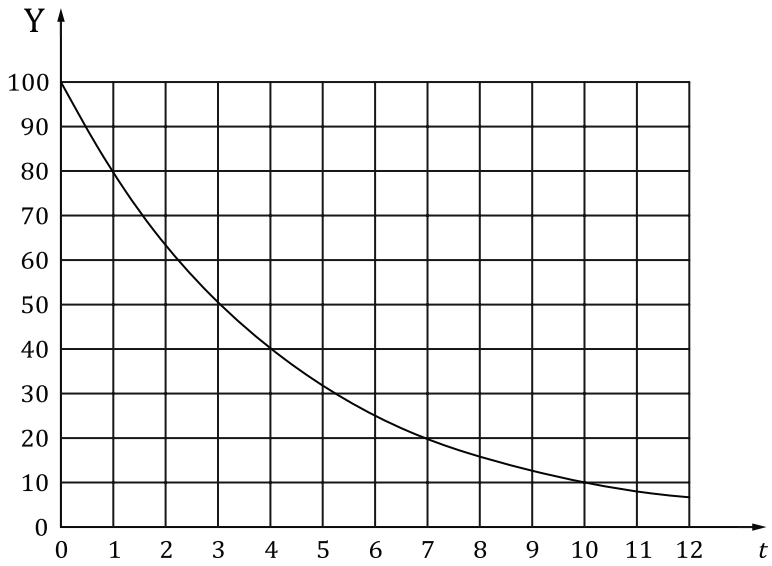
Key

1 coverage
2 vision panel
3 frame
4 steel sheet
5 frame profile

Figure A.31

Polycarbonate screens should be protected against ageing effects, e.g. by addition of a safety glass screen towards the machining side and a plastic screen towards the access side. The edges of the screens shall be sealed. The limited service life of polycarbonate screens shall be indicated in the instruction handbook.

NOTE All-around protected polycarbonate panels show only marginal loss of impact resistance, whereas the curve shows that the impact resistance of unprotected polycarbonate is significantly reduced (see Figure A.32).



Key

Y impact resistance in %

t lifetime in years

Figure A.32 — Ageing curve of unprotected polycarbonate (averaged test points) (Source: IFA, St. Augustin, Germany [01])

A.3.7 Verification of strength, testing

A.3.7.1 Abrasive product guards

Abrasive product guards which do not comply with the specifications set out in A.3.2 shall be tested to verify their strength. The test shall be carried out in accordance with the following methods:

a) mounting of the guard;

b) the guard shall be mounted for the test so that its position and fixing elements correspond to its intended use on the grinding machine;

c) an abrasive product shall be used, which corresponds in its design type and dimensions to its intended use on the grinding machines;

d) breakage of the abrasive product shall be initiated at the intended maximum operating speed or the permissible speed of rotation by a projectile shot onto the abrasive product or by another suitable procedure. The projectile shall hit the abrasive product near the clamping device (flange);

e) the test shall be carried out with three abrasive products in succession using the same guard.

Sufficient strength is verified if the guard and its clamping elements remain in function not showing any visible cracks when examined by a recognized method of crack detection, e.g. dye penetration or magnetic crack detection. Minor deformations and surface damage can be accepted. Fixing devices, e.g. clamping devices, bolts, shall remain in function with no detectable damage.

A.3.7.2 Work zone enclosures

Work zone enclosures not complying with the requirements in A.3.5.2 shall be tested for verification of their strength or their impact resistance to abrasive product fragments. For test methods, see

Annexes B and C. For calculation of the wall thicknesses as provided in A.3.5.2, the values determined in the individual verification may be used.

A.4 Criteria for the design of abrasive product guards and their means of attachment

A.4.1 General

The energy of the fragments resulting from an abrasive product breakage is the basic criterion for the design of abrasive product guards and means of attachment, since the energy of the fragments is transmitted

— directly or indirectly (by means of ejection of colliding fragments) to the abrasive product guard,

— via the abrasive product guard to its means of attachment and the machine frame, and

— via wheel dressers which can project into the abrasive product guard, indirectly to the spindle head and the machine frame.

Methods for the calculation of the energy of abrasive product fragments and for the determination of wall thicknesses of abrasive product guards and the design of the means of attachment for abrasive product guards are described in the following subclauses.

A.4.2 Energy of abrasive product fragments

The calculation of the impact energy transmitted in the case of an abrasive product breakage from the fragments to the abrasive product guard is only possible by approximation. Its value depends among others on the breakage behaviour of the abrasive product.

The energy of a rotating abrasive product is

$$E = \frac{1}{4} m\ (1 + Q^2) \times v^2 \tag{A.1}$$

and is contained in the fragments as translational and rotational energy. On the assumption that the resulting fragments are equal in size, the following formula applies:

$$E = z \times (E_{\text{trans}} + E_{\text{rot}}) \tag{A.2}$$

The translational energy of a fragment being

$$E_{\text{trans}} = \frac{2}{9 \times \pi} \times m \times \frac{\left(1 - Q^3\right)^2}{\left(1 - Q^2\right)^2} \times \frac{(\sin\alpha)^2}{\hat{\alpha}} \times v^2 \tag{A.3}$$

For a half angle of fragments α = 67°, the translational energy reaches its maximum value:

$$E_{\text{trans}}(\alpha = 67°) = 0,051 \times m \times \frac{\left(1 - Q^3\right)^2}{\left(1 - Q^2\right)^2} \times v^2 \tag{A.4}$$

The rotational energy of a fragment is calculated as

$$E_{\text{rot}} = \frac{E}{z} - E_{\text{trans}} \tag{A.5}$$

NOTE For symbols, see A.2.

A.4.3 Determination of the wall thicknesses of abrasive product guards

A theoretical model for the calculation of the wall thicknesses of abrasive product guards is not available. Therefore, the determination of the wall thickness values in Tables A.1 to A.6 is based partly on experience and partly on available experimental test results. The procedure is described below.

The basic criterion for the dimensioning of the abrasive product guards wall thickness is the translational fragment energy in accordance with Formula (A.4), using the mass and dimensions of the new abrasive product and the highest possible peripheral speed of the abrasive product in case of failure of the wheel spindle drive.

Required wall thickness and fragment energy were related on the basis of the wall thickness tables in national regulations of Germany, England, and France valid when EN 13218:2002 was developed. The fragment energy anticipated for the abrasive products listed in these wall thickness tables was calculated using the above mentioned formula. The corresponding value from the tables for the wall thickness of the abrasive product guard was assigned to this calculated energy value. The wall thickness was represented in a diagram as a function of the fragment energy with the abrasive product guard material as parameter.

The diagram showed a considerable correspondence between the requirements. However, it explains that in all Tables considered, the energy values assigned to the wall thickness values show a wide scatter.

In order to assign the wall thickness unambiguously to the fragment energy, the revealed variations were approximated by means of compensating functions, additionally using experimental studies and experiences with wall thicknesses which have until present been used in praxis.

This empirical procedure resulted in the following relationships between the wall thickness t_p of the peripheral part of the abrasive product guard and the fragment energy E_{trans} of the abrasive product for the different guard materials in accordance with Table A.7:

Steel sheet:
$$t_p = 0,4\ E_{trans}^{0,37}\ (E_{trans} \langle 100\,000\,\text{Nm})$$

Cast steel:
$$t_p = 0,57\ E_{trans}^{0,37}\ (E_{trans} \langle 100\,000\,\text{Nm})$$

Cast iron:
$$t_p = 0,92\ E_{trans}^{0,37}\ (E_{trans} \langle 6\ 000\,\text{Nm})$$

Wrought aluminium alloy:
$$t_p = 0,7\ E_{trans}^{0,37}\ (E_{trans} \langle 3\,300\,\text{Nm})$$

Cast aluminium alloy:
$$t_p = 1,8\ E_{trans}^{0,37}\ (E_{trans} \langle 1\ 300\,\text{Nm})$$

In these formulae, the energy value E_{trans} shall be given in Nm, the wall thickness value t_p will then be in mm.

The energy values given in brackets are limit values; there is no experience on the applicability of the above formulae for higher values.

The wall thicknesses given in Tables A.1 to A.6 were determined by means of these approximation functions. The following assumptions were taken as basis for the calculation of the fragment energy in accordance with Formula (A.4):

Tables A.1 to A.4: Abrasive product type 1 or 41 in accordance with ISO 525

Q = 0,2 for $D \leq 508$ mm

Q = 0,4 for $D \geq 610$ mm

Q = ratio of bore diameter H and outside diameter D of the abrasive product

Semi angle of fragment α = 67°

Density of abrasive product ρ = 2,4 g/cm^3

Table A.6: Superabrasive type 1A1 in accordance with ISO 6104

Depth of superabrasive section X = 6 mm

Q = ratio of core diameter (D-2X) and outside diameter D of the abrasive product

Semi angle of fragment α = 15°

Density of abrasive product section ρ = 8,6 g/cm^3 (metal bond)

Exclusion of errors for core

Exclusion of errors for the core of superabrasive products is only permissible if the abrasive product corresponds to the requirements of EN 13236 or to comparable requirements.

Based on data given in national tables and previous experience, a ratio t_s/t_p = 0,75 was assumed as the basis for calculation of the wall thicknesses t_s of the side parts of the abrasive product guards. The wall thickness values determined by calculation were rounded to whole or half millimetre values in the Tables.

This procedure is also applicable for the dimensioning of abrasive product guards for abrasive product dimensions and peripheral speeds not listed in Tables A.1 to A.6 and for abrasive products with densities differing from those given above. The limits of the formulae-dependent relationships shall be observed.

A.4.4 Design of the means of attachment of abrasive product guards

To simplify matters, only the translational fragment energy is taken into account for the design of the means of attachment. For safety reasons, however, the calculation is carried out with a peripheral speed which exceeds the maximum peripheral operating speed by 30 %. Consequently, Formula (A.4) is modified for this calculation as follows:

$$E_{\text{trans}}(\alpha = 67°) = 0,086 \times m \times \frac{\left(1 - Q^3\right)^2}{\left(1 - Q^2\right)^2} \times v^2 \qquad \text{(A.6)}$$

It can, however, be taken into account that in the case of impulsive stress of a static mass, losses of energy can result due to plastic deformation:

$$\Delta E = \frac{m_{\text{SH}}}{m_{\text{Br}} + m_{\text{SH}}} \times \left(1 - k^2\right) \times E'_{\text{trans}} \qquad \text{(A.7)}$$

The coefficient of impact k varies between k = 0 (plastic impact) and k = 1 (elastic impact). The coefficient of impact k can be reduced within certain limits by plastically deformable materials and elements as e.g. rigid expanded polyurethanes or thin-walled round tubes, which are integrated into the abrasive product guard as lining. Practical tests have e.g. shown a coefficient of impact k = 0,75. The thickness of the deformation elements shall be at least equal to that of the abrasive product. The ratio of the lining thickness and the wall thickness of the abrasive product guard (Tables A.1 to A.5) should be about 4:1 for a strength of the expanded polyurethane of 180 N/cm^2. Rigid obstructions in the abrasive product guard, e.g. welded stabilizing webs should, however, be avoided.

Containing safety devices are so connected to the grinding machine that these parts remain connected in the case of an abrasive product breakage. It shall be ensured that the energy absorbing capacity of

the total number of n fixing elements exceeds the energy value determined by the calculation method, i.e. the condition

$$\sum_{i=1}^{n} W_i \rangle E'_{\text{trans}} - \Delta E \tag{A.8}$$

shall be fulfilled.

Tensile impact stress

In the case of tensile impact stress, reduced shaft bolts are used. The energy absorption capacity of a cylindrical reduced shaft bolt, i.e. a highly elastic screw (material quality 8.8, 10.9, or equivalent), is approximately calculated as Formula (A.9):

$$W_{\text{D}} = A_{\text{T}} \times l_{\text{s}} \times \sigma_{\text{m}} \times \varepsilon_{\text{B}} \tag{A.9}$$

with Formula (A.10):

$$\sigma_{\text{m}} = \frac{R_{\text{eH}} + R_{\text{m}}}{2} \tag{A.10}$$

R_{eH} is e.g. $R_{\text{p0,2}}$

Shearing impact stress

If possible, fixing screws shall not be submitted to shearing stress by the fragment energy, as the energy absorption capacity is very small under these conditions. If special means of attachment are integrated, it shall be guaranteed that the provided shearing area is large enough. The energy absorption capacity of a shearing element is approximately

$$W_{\text{s}} = F_{\text{m}} \times s_{\text{w}} \tag{A.11}$$

for shearing elements with circular section, the average shearing force is

$$F_{\text{m}} = \frac{2}{3} \times F_{\text{max}} \tag{A.12}$$

with the maximum shearing force

$$F_{\text{max}} = \tau_{\text{s}} \times A_{\text{s}} \tag{A.13}$$

the shearing distance is

$$s_{\text{w}} = 0{,}3 \times d \tag{A.14}$$

Annex B
(informative)

Impact test for guards — Bursting test

B.1 General

This Annex specifies tests for guards used on grinding machines in order to minimize risks of ejection of parts or workpieces out of the work zone.

This Annex applies to guard materials, as well as to complete guards.

B.2 Test method

B.2.1 Principle

This test method applies to machines operated with abrasive products without abrasive product guard and reproduces the hazard of the ejection of abrasive product fragments. The test shows the resistance/strength of guards and/or guard materials against penetration and dislodgement

In this test method, the hazardous event is reproduced by intentionally initiated bursting of abrasive products used on the machine.

B.2.2 Test conditions

a) In the test, bursting of an abrasive product is initiated at at least 1,2 times the maximum possible spindle speed of the relevant grinding machine. If safe limitation of the maximum speed for the relevant abrasive product diameter according to 5.12. b) 5) is ensured, the test may be carried out with the above limited maximum speed multiplied by 1,2.

NOTE A peripheral speed of the abrasive product is assumed which is 20 % above the maximum possible spindle speed or the peripheral speed resulting from the safely limited maximum spindle speed. This “safety factor” covers the following:

- dispersions of the material characteristics of the materials of the samples or the guards;
- insecurities due to increased speeds/peripheral speeds when shutting-down spindle drives by delays due to time intervals required by signal processing in the control system;
- the “central impact” is not the most critical case of stress;
- low number of impact tests required for the determination of the impact resistance;
- insecurities in the determination of the spindle speed of the test device.

b) An abrasive product shall be used, the type (shape, hardness, porosity) and mass of which corresponds to the abrasive products intended for use on the grinding machine. The abrasive product presenting the highest hazard potential shall be used.

c) The test samples shall be arranged radially in the direction of flight around the abrasive product.

d) As the translational fragment energy is at maximum, if the mass of the fragment is about one third of the mass of the abrasive product, fragments with approximately one third of the total mass of

the abrasive product should be produced. This may be achieved by preparing the abrasive product with defined saw cuts.

e) The distance of the test samples to the wheel spindle should approximately correspond to the distance between abrasive product and guard on the actual grinding machine.

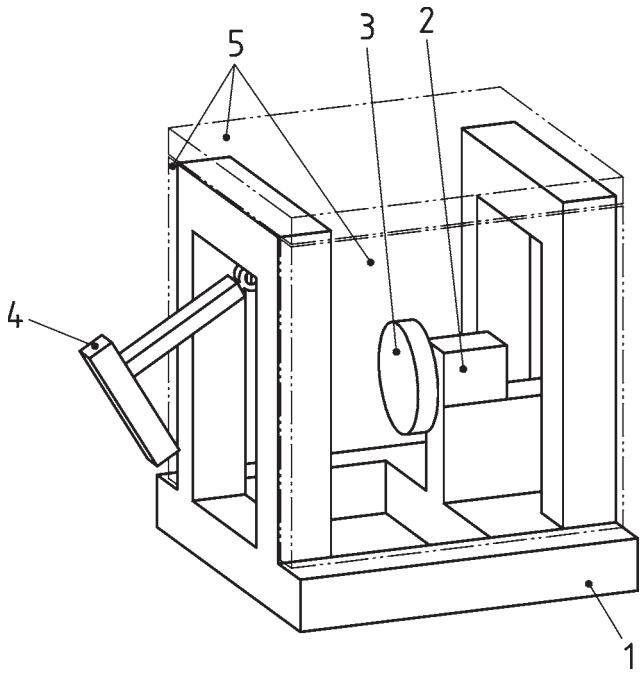
f) Number of tests: As the directions of flight and thus the impact positions of the abrasive product fragments are coincidental, it has to be tested (e.g. by means of high-speed photographs), if a test sample was hit by at least one 1/3 fragment on the surface. If no such hit is realized, the test shall be repeated. In order to increase the probability of hits, several test samples per test could be arranged in the direction of flight

B.2.3 Test device

The test device (see Figure B1) mainly consists of a power operated spindle with abrasive product holding device which accelerates the abrasive product to the relevant speed or peripheral speed.

The speed shall be controlled by measurement.

In addition, the test equipment consists of a device, which initiates bursting of the abrasive product, e.g. a falling weight. The test device also includes a frame for fixing the test samples.



Key

1 frame
2 spindle
3 abrasive product
4 bursting device
5 test sample

Figure B.1 — Example for a test device for the impact test

B.2.4 Test sample

Both material samples and guards ready for use may be test samples.

The test samples subjected to the impact shall correspond to the material and the structural construction of the guard of the actual grinding machine at its weakest area.

If the interfaces between two elements of the guard are tested, the test samples shall present the relevant interfaces which shall be arranged on the test equipment in such a way that the abrasive product fragments hit directly beside the interface.

As to the vision panels, not only the pure impact resistance shall be tested. Another decisive factor is the attachment of the vision panel to the surrounding wall construction.

Therefore, vision panels to be tested shall be mounted on a frame corresponding to the structure of the guard of the grinding machine in analogy to the way they are mounted on the actual machine (particularly with regard to material overlap and fixing elements).

As larger vision panels bulge more than small ones during impact and thus require another minimum overlap, the tests shall be carried out with vision panels, the outside dimensions of which approximately correspond to those of the vision panels used on the actual grinding machine. Deviations of ±15 % are acceptable.

B.3 Results

After the impact, the damages identified on the test sample shall be assessed as follows:

B.3.1 Damages can be:

a) buckling/bulging (permanent deformation without crack);

b) incipient crack (visible only on one surface);

c) through crack (crack visible from one surface to the other);

d) penetration (projectile penetrating the test object);

e) guard window loosened from its fixing;

f) guard loosened from guard support.

B.3.2 Assessment

The test is passed if there is no through crack or penetration of the test object and no damage of types e) and f) according to B.3.1.

B.4 Test report

The test report shall specify the following minimum information:

a) the date, place of the test, and name of the testing institute;

b) the mass, dimensions, and strength of the abrasive product and bursting and peripheral speeds;

c) the design, material, and dimensions of the test object;

d) the clamping or fixing of the test object to test facility;

e) the test result with indication of the damage figures.

Annex C
(informative)

Impact test for guards — Projectile impact

C.1 General

This Annex specifies tests for guards used on grinding machines in order to minimize risks of ejection of parts or workpieces out of the work zone.

This Annex applies to guard materials, as well as to complete guards.

C.2 Test method

C.2.1 Principle

This test method applies to machines operated with abrasive products without abrasive product guard and reproduces the hazard of the ejection of abrasive product fragments. The test shows the resistance/strength of guards and/or guard materials against penetration and dislodgement.

In this test method, the hazardous event is reproduced by the impact on the guard of a projectile, the impact energy of which corresponds to the translational energy of an abrasive product fragment of 134°.

C.2.2 Test conditions

a) For the determination of the impact energy of the projectile, the abrasive product intended for use on the machine which presents the highest hazard potential shall be taken as basis.

b) The required impact energy corresponds to the translational energy of the 134° fragment of this abrasive product, determined by Formula (A.4), assuming a peripheral speed of the abrasive product of 1,2 times the maximum possible spindle speed of the relevant grinding machine. If safe limitation of the maximum speed for the relevant abrasive product diameter according to 5.12 b) 5) is ensured, the test may be carried out with above limited maximum speed multiplied by 1,2.

NOTE For the calculation of the required impact energy of the projectile, a peripheral speed of the abrasive product is assumed which is 20 % above the maximum possible spindle speed or the peripheral speed resulting from the safely limited maximum spindle speed. This “safety factor” covers

- dispersions of the material characteristics of the materials of the samples or the guards,
- insecurities due to increased speeds/peripheral speeds when shutting-down spindle drives by delays due to time intervals required by signal processing in the control system,
- the “central impact” is not the most critical case of stress, and
- low number of impact tests required for the determination of the impact resistance.

c) The mass of the projectile shall be about the mass of the 134° fragment of the abrasive product specified under a). The diameter of the projectile should approximately correspond to the width of the relevant abrasive product.

d) The required speed of the projectile is calculated from the translational energy determined under b) and the mass according to c) with the formula $v = \sqrt{\frac{2E}{m}}$

with v = projectile speed = impact speed

E = impact energy calculated in accordance with b)

m = mass of projectile in accordance with c).

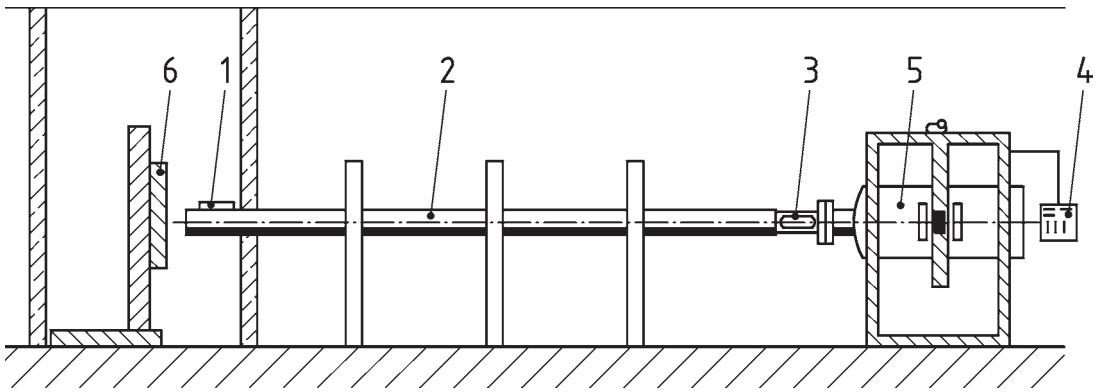
C.2.3 Test equipment

The test equipment consists of a gun, a projectile, and a support of the guard to be tested.

C.2.3.1 Gun

The gun can consist of a compressed-air vessel with a flanged gun barrel (see Figure C.1). Compressed air can be released by a valve to accelerate the projectile toward the test object. The air gun is fed by an air compressor. The speed of the projectile can be controlled by the pressure of the air. The drive or thrust unit shall enable acceleration of the projectile to ±5 % of a given impact speed.

Projectile speed is measured near the muzzle of the gun barrel by a suitable velocimeter, e.g. by proximity sensor or photocell.



Key

1 velocimeter
2 gun barrel
3 projectile
4 control panel
5 compressed-air vessel
6 test object

Figure C.1 — Equipment for impact test

C.2.3.2 Projectile

Shape, mass, and dimensions of standardised projectiles are given in Figure C.2 and Table C.1.

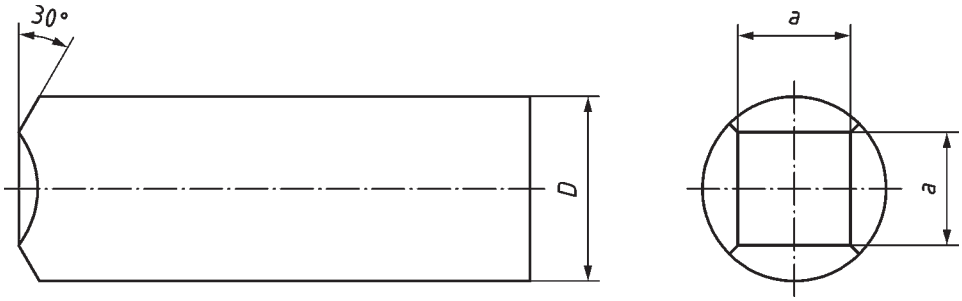
The specification of projectile material, mass, and shape is done on the basis of the following:

— projectile material corresponding to the abrasive product material specified in C.2.2.a);

— projectile mass and diameter as specified in C.2.2 c);

— projectile front face as specified in Figure C.2 and Table C.1.

If the determined projectile parameters correspond to the standardised projectiles from Table C.1, the standardised projectiles can be used. Otherwise, projectile geometries which are reduced or enlarged accordingly shall be specified.



NOTE The projectile is hardened to 56^{+4}_{-0} HCR over depth of at least 0,5 mm.

Figure C.2 — Projectile

Table C.1 — Projectile, mass, and dimensions

Projectile		
Mass **m**	**Diameter** *D*	**Front face** *a* × *a*
kg	mm	mm × mm
0,625 1,25 2,5	30	19 × 19
	30	19 × 19
	40	25 × 25
	50	30 × 30
	30	19 × 19
	50	30 × 30
	60	38 × 38
	70	45 × 45

C.2.3.3 Speed measurements

The speed of the projectile shall be measured at a point where it is no longer subject to acceleration (i.e. after exiting the barrel or in the barrel beyond suitable pressure relief). The speed needs to be measured over a fixed distance using proximity sensors, photoelectric cells, or other equivalent means.

C.2.3.4 Supporting the guard under test

The test is carried out with the guard and/or a sample of the guard material. The guard support shall be equivalent to the guard mounting on the machine. For testing guard materials, samples can be used, fixed on a frame with an inner opening of 450 mm × 450 mm. The frame shall be sufficiently rigid. The mounting of the sample shall be by non-positive clamping.

C.2.4 Test procedure

In order to evaluate the resistance class of a guard, a projectile has to be shot against a material sample and the impact shall be in the centre of the sample and as perpendicular to the surface as possible. For the test on real machine guards, the impact shall be in the weakest area of the guard.

C.3 Test results

After the impact, any damage found on the guard or material shall be assessed as follows.

C.3.1 Damages can be:

a) buckling/bulging (permanent deformation without crack);

b) incipient crack (visible only on one surface);

c) through crack (crack visible from one surface to the other);

d) penetration (projectile penetrating the test object);

e) guard window loosened from its fixing;

f) guard loosened from guard support.

C.3.2 Assessment

The test is passed if there is no through crack or penetration of the test object and if there is no damage of types e) and f) according to C.3.1.

C.4 Test report

The test report shall specify the following minimum information:

a) the date, place of the test, and name of the testing institute;

b) the projectile mass, dimensions, speed;

c) the machine manufacturer, type, maximum diameter, maximum spindle speed, mass, and dimensions of the abrasive product, the failure of which is to be reproduced by the impact;

d) the design, material, and dimensions of the test object;

e) the clamping or fixing of the test object;

f) the direction of shock, point of impact of the projectile;

g) the test result.

Annex D
(normative)

Clamping methods for abrasive products and safety requirements for tool holding devices

D.1 General

The following statements include safety requirements for devices for the mounting of abrasive products on grinding machines.

D.2 Clamping methods

Clamping methods are for example:

— by means of flanges. See Figures D.7 to D.15;

— by means of inserted nuts. See Figures D.13 to D.15;

— by means of clamping ring or chucking tool at the outside of the abrasive product. See Figure D.16;

— by means of cementing to a back plate. See Figures D.17 and D.18;

— by means of segments mounted on a clamping fixture. See Figures D.19 and D.20.

D.3 General requirements

The clamping devices shall transmit the maximum required operating torque at minimum clamping pressure. The following general requirements shall be fulfilled:

— The design of flanges shall guarantee that the contact areas are perpendicular to the rotational axis when clamped (except for tapered wheels type 4);

— The clamping force shall be equally distributed all over the clamping area. The contact areas shall be flat and free from burrs. The concentricity with the rotational axis should be ≤0,02 mm;

— There shall always be an undercut at the inner diameter of the clamping area. This undercut shall be minimum 1 mm, for abrasive products with $H > 0{,}2$ D minimum 4 mm;

— The clamping device shall be marked in accordance with D.4.4.

D.4 Design of flanges

D.4.1 Clamping forces and tightening torques

The design of the dimensions can successfully be made by finite element modelling (FEM) method or equivalent methods. As an alternative for the design, D.4.2 gives some guidance that may be used.

D.4.2 Outside clamping diameter, radial width and covering

The specification of the outside diameter D_F of the flanges shall be carried out in compliance with Tables D.1 to D.3 as a function of abrasive product, type of machine and maximum operating speed. In addition, it shall be guaranteed that at least 1/6 of the radial width M of the abrasive product (Figure D.1) is

covered by the clamping flange ($R \geq 0{,}17\ M$). For straight recessed flanges, the annular contact area shall at least have a width R of 1/6 of the flange diameter ($R \geq 0{,}17\ D_F$), (Figure D.2).

For the design of hub flanges (Figure D.1), see also ISO 666.

Table D.1 — Flange diameters for bonded abrasive products and for superabrasive products with vitrified core (with the exception of cutting-off wheels)

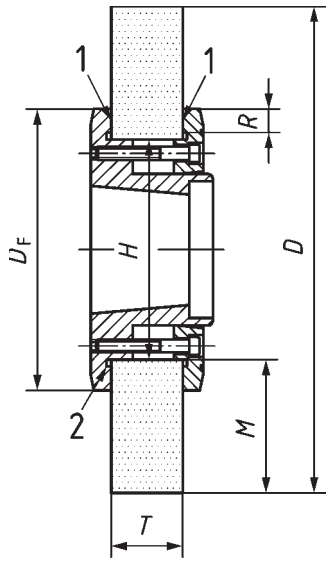
Type of machine	Abrasive product			Maximum operating speed	Flange outside diameter
	Designation	Dimensions in mm	Bond	v_s m/s	D_F mm
Stationary grinding machines	Plain wheels, dish and saucer wheels, cup wheels	$H \leq 0{,}2 \cdot D$	all	all	$\geq 0{,}33 \cdot D$
		$H > 0{,}2 \cdot D$			$\geq H + 2 \cdot (0{,}17 \cdot M)$[a]
D = outside diameter of abrasive product H = abrasive product bore M = radial width of abrasive product $\left(\frac{D-H}{2}\right)$					
[a] See ISO 666.					

Table D.2 — Flange diameters for bonded abrasive cutting-off wheels

Type of machine	Abrasive product			Maximum operating speed	Flange outside diameter
	Designation	Dimensions in mm	Bond	v_s m/s	D_F mm
Stationary cutting-off machines	Plain cutting-off wheels	$D \leq 800$	B, BF	≤63	$\geq 0{,}2 \cdot D$
				80, 100	$\geq 0{,}25 \cdot D$
				125	$\geq 0{,}33 \cdot D$
		$D > 800$	BF	≤63	$\geq 0{,}2 \cdot D$
				80, 100, 125	$\geq 0{,}33 \cdot D$
	Depressed-centre cutting-of wheels	all D	BF	≤ 100	≥0,25 D at least $H + 2 \cdot (0{,}17 \cdot M)$
Swing frame cutting-off machines	Plain and depressed-centre cutting-off wheels	$D \leq 600$	BF	≤80	

Table D.3 — Flange diameters for superabrasive cutting-off wheels with metal core

Type of machine	Abrasive product			Maximum operating speed	Flange outside diameter
	Designation	Dimensions in mm	Bond	v_s	D_F
				m/s	mm
Stationary cutting-off machines	Straight cutting-of wheels	$D \leq 600$	G, M	≤200	≥0,18 · D, at least 41
			B	≤140	
		600 < D ≤ 1 500	M	≤125	≥0,18 · D
		D > 1 500			≥0,10 · D, at least 270



Key

1 flexible blotters

2 undercut

Figure D.1 — Clamping flanges for mounting abrasive products with large bore
(H > 0,2D)

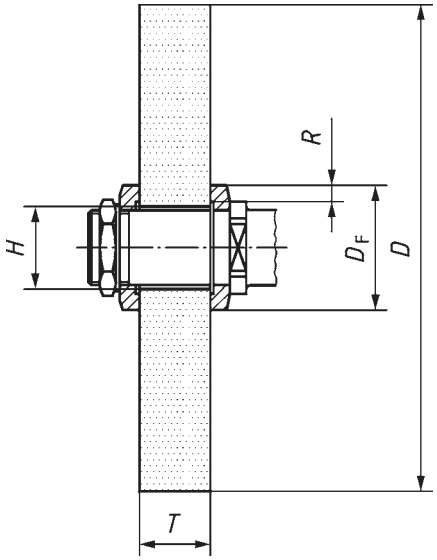


Figure D.2 — Clamping flanges for mounting abrasive products with small bore
($H \leq 0{,}2D$)

D.4.3 Stiffness

D.4.3.1 General

Flanges shall have sufficient stiffness to ensure a homogenous distribution of the force over the whole contact area when clamped. A flange is considered to be sufficiently stiff, if its clamping area is parallel to the underlying surface when the test force F_c is applied ($\lambda \leq 0{,}005$). The test procedure is described in D.4.3.2. Flanges complied with ISO 666 are considered to have enough stiffness, therefore the measurement of the stiffness is not required in this case.

D.4.3.2 Method for measuring the stiffness

The applied test force shall have the value F_c corresponding to the clamping force F_E calculated by the manufacturer and considering the properties of the abrasive product.

Execution of the measurement:

a) Place the flange on a measuring table (permissible flatness deviation 0,01/100), the contact area being in contact with the measuring table.

b) Place two dial gauges, one normal to the recess diameter, the other at 1 mm from the outside diameter for $D_F \leq 200$ or at 2 mm for $D_F > 200$ mm.

c) Using a plain washer offering a similar contact area to that of the nut or the multiple screw system clamping the flange (see notes),

   — apply the test force F_c

   — reduce that force to pre-load value corresponding to 1/10 of the test force and set the dial gauges to 0.

For hub flanges clamped with a multiple screw system, the load shall be transmitted to the flange by pins placed normal to the screws.

d) Note the algebraic value of displacement C_1 and C_2, as indicated by the dial gauges, with F_c being the test force (Figure D.3).

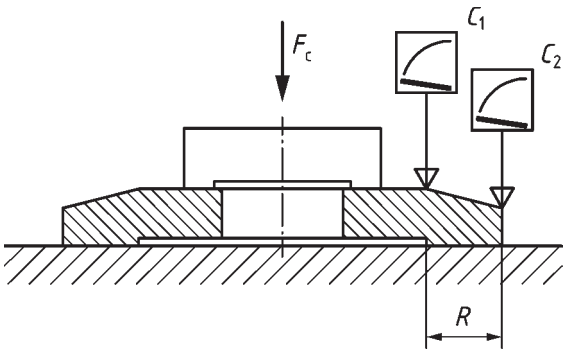


Figure D.3 — Test arrangement

e) Remove the test force while maintaining the pre-load. The dial gauge pointers should come back to their original position.

f) Carry out three measurements at 120° from each other.

g) Calculate the ratio

$$\lambda = \frac{|C_1 - C_2|}{R}$$

(C_1, C_2 and R in millimetres).

D.4.4 Marking of flanges

For abrasive products with outside diameter D > 200 mm, the flanges shall bear the following indications, which shall still be visible after mounting the abrasive product:

— maximum outside diameter D of the abrasive product;

— maximum and minimum width T of the abrasive product;

— diameter H of abrasive product bore.

D.5 Devices for the mounting of abrasive products by means of clamping inserts

D.5.1 Central threaded inserts

Supporting flanges for the mounting of abrasive products with central threaded inserts shall have flat contact areas with the abrasive products. The run-out tolerance with the rotational axis should be ≤0,02 mm.

The outside diameter D_F of the supporting flanges shall be at least 0,33 D of the maximum outside diameter of the abrasive product for the mounting of plain and tapered cup wheels (Figure D.4).

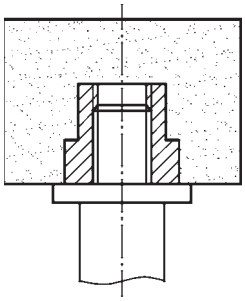


Figure D.4 — Cup wheels

Collets for the mounting of abrasive products with inserted steel spindle shall bear indications on the clamping diameter and the length of the spindle within the clamp. They shall ensure sufficient concentricity of the clamped spindle. This requirement is considered fulfilled if the permissible run-out tolerances in accordance with Table D.4 are not exceeded when using the test procedure described under D.5.2.

D.5.2 Method for the determination of the run-out tolerance for collets

After mounting the collet in a test spindle, a test shaft, h5, is mounted in the collet (Figure D.5).

The run-out tolerance of the test shaft is determined at a distance *l* (test length) from the clamping position, e.g. by means of a dial gauge, and compared with the corresponding test value.

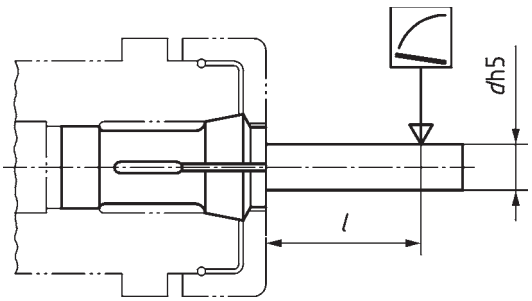


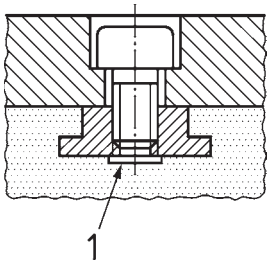
Figure D.5 — Test shaft

Table D.4 — Permissible run-out tolerance for collets

Clamping diameter in mm	Test length *l* in mm	Permissible run-out tolerance in mm
more than 1,6 to 3	10	0,02
more than 3 to 6	16	0,02
more than 6 to 10	25	0,02
more than 10 to 18	40	0,03

D.5.3 Inserts for abrasive products type 2, 35, 36, 37 (see EN 12413) and comparable abrasive products

The inserted nut of the abrasive product shall have enough area to touch the steel of the backplate, and the guidance of the bolt shall be such that no bending or breaking out of inserted nuts take place. The bolt end shall not reach the bottom of the inserted nut nor reach the abrasive body. There shall always be a clearance between the bolt and the bottom of the nut/abrasive body. See Figure D.6.



Key

1 end of the bolt shall not reach the bottom of the nut

Figure D.6 — Correct nut and bolt arrangement

Figures D.7 to D.19 are showing different examples for holding of abrasive products.

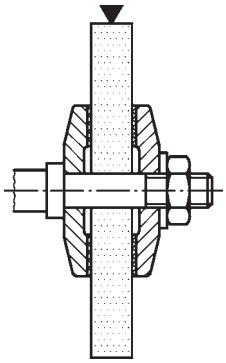


Figure D.7

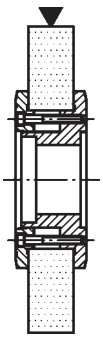


Figure D.8

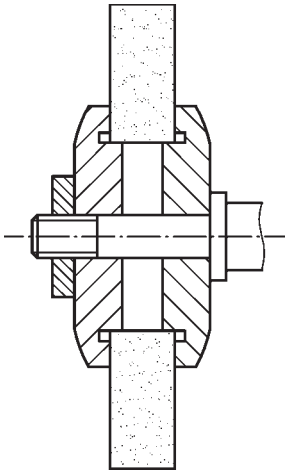


Figure D.9

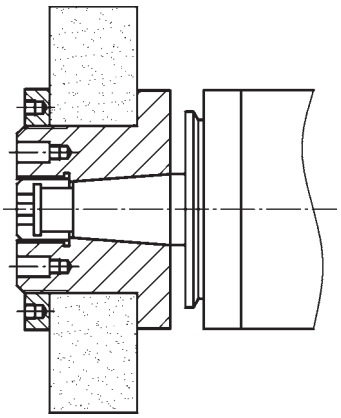


Figure D.10

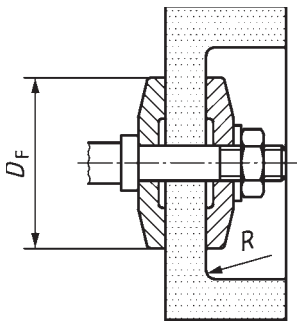
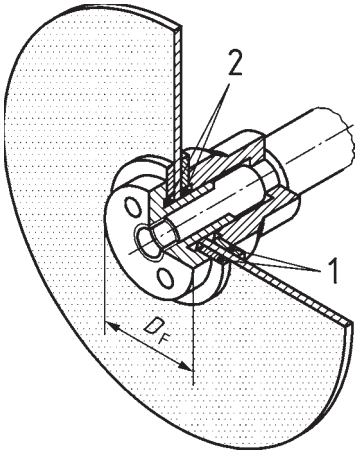


Figure D.11

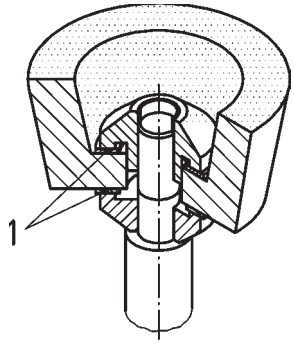


Key

1 intermediate layers

2 undercut

Figure D.12



Key

1 intermediate layers

Figure D.13

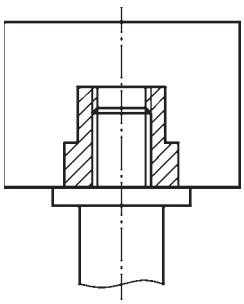
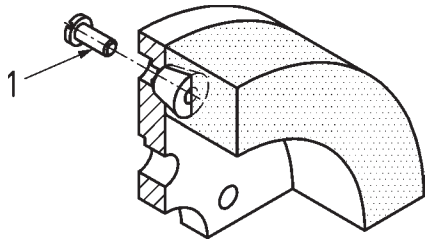


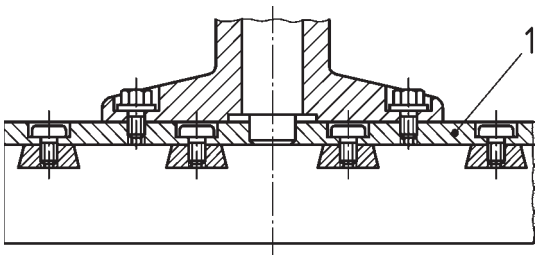
Figure D.14



Key

1 end of the bolt shall not reach the bottom of the abrasive product

Figure D.15



Key

1 backplate

Figure D.16

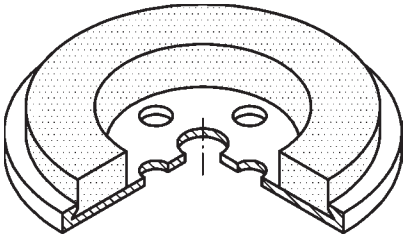
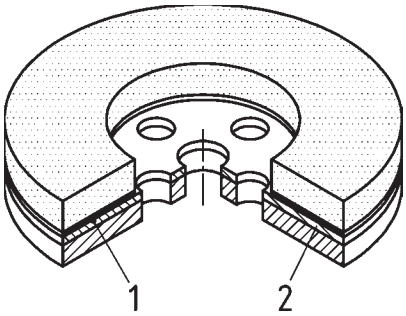


Figure D.17

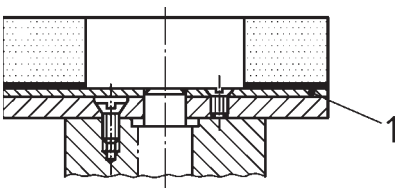


Key

1 backplate

2 glue

Figure D.18



Key

1 glue

Figure D.19

Figures D.20 and D.21 are showing examples of segmented abrasive products.

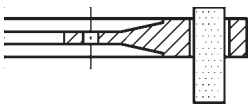


Figure D.20

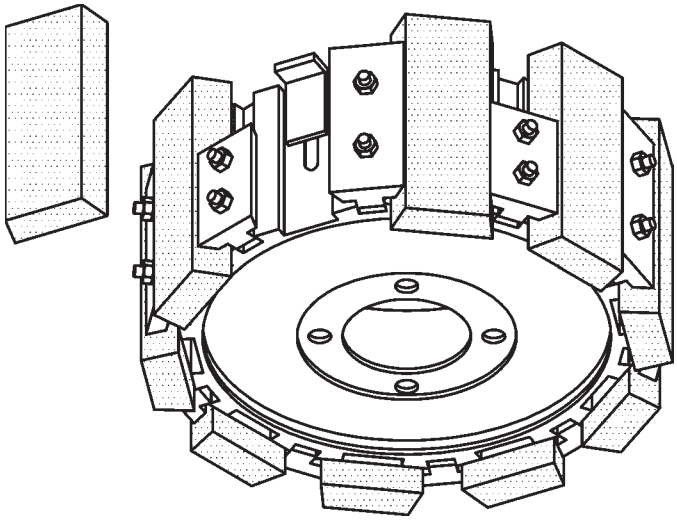


Figure D.21

Annex E
(informative)

Noise reduction

The following list contains examples of measures for the reduction of noise emission at the design stage. It is not meant to be exhaustive. Alternative measures for noise control with identical or greater efficiency can be used by the manufacturers.

Noise emission can be reduced by the following:

— Prevention of vibration

  Use of balanced tools and sufficient support of the tool, e.g. by means of flanges with high rigidity and large outside diameter.

— Prevention of vibration transmission

  If vibration cannot be avoided by means of constructive measures, their transmission to the environment shall be reduced by isolation of the vibration element by means of vibration isolators.

— Reduction of flow noise

  By means of sound absorbers for gaseous substances at outlet openings or for relaxation processes (e.g. use of compressed air for pneumatic controls).

  Use of multi-hole nozzles for compressed air, e.g. for the blasting of clamping devices for tools and workpieces.

— Prevention of turbulence

  Aerodynamic design of rapidly rotating parts, e.g. closed surfaces, if possible, prevents the generation of turbulences and the resulting squealing of mostly high frequencies.

— Reduction of sound propagation

  Sound insulating/attenuating enclosures reduce the propagation of airborne noise from the noise source to the environment. They can either enclose the whole machine tool or the individual noise source (e.g. hydraulic unit, machining zone, driving motors.)

  The efficiency of enclosures will be considerably reduced by openings, e.g. air inlets or outlets, loading and unloading openings.

  A sound propagation can also be reduced by partial enclosures. Noise-absorbing materials are applied to the internal surfaces of machine enclosures around the noise source, e.g. at internal surfaces of the machine casing in the surroundings of the ball roller spindle.

Annex F
(informative)

Noise emission determination

F.1 Method

General information and basic measuring procedures for the determination of the sound pressure level and the sound power level on machine tools is contained in ISO 230-5.

As an environmental correction K_2, the sound power level will be determined by means of the reflecting plane method in accordance with ISO 3744 or ISO 3746. The sound pressure level at workstations will be determined in accordance with ISO 11201, ISO 11202, or ISO 11204. The determination of the sound pressure level will be effected at that position in the direct vicinity of the machine which is indicated in the instruction handbook as the position for the use of the operator.

F.2 Operating conditions

Operating conditions for noise measurements have not yet been specified for the grinding machines dealt with in this International Standard. These conditions will be included at a later date in a special Annex to this International Standard. Until these specifications are available, the manufacturer will describe in detail the operating conditions and the abrasive products and workpieces used when declaring noise emission values.

It can be useful to carry out the noise emission measurement under several typical operating conditions. Until appropriate specifications in standards are available, measurements should at least be carried out in "no-load" operation mode, under the following conditions:

— maximum operating speeds of the abrasive product;

— highest possible speeds of axes;

— maximum coolant pressures or flows;

— maximum extraction power.

In addition to this,

— all additional devices (as e.g. chips conveyors, coolant system, hydraulic, and lubricating systems) should be put into service during the measurement, and

— all protective devices, especially those designed for reduction of noise emission and delivered with the machine, shall be installed during the measurement, and shall be in "protection" position.

For any determination of the sound pressure level at workstations and of the sound power level, identical mounting and operating conditions will be used.

NOTE Achievable noise emission values for the grinding machines covered by this International Standard can at present not be stated, as until now, no systematic recording, collecting, and evaluation of noise declarations in accordance with ISO 11689 has been carried out.

Annex G
(normative)

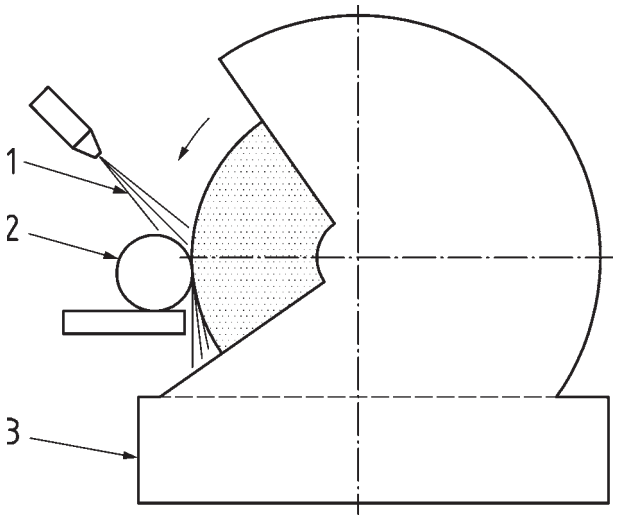
Requirements for grinding machines for the machining of materials generating flammable and explosive dusts

G.1 Devices for wet grinding

The machine shall be equipped with devices for the supply of water or other suitable metalworking fluids directly to the machining point. The dimensioning of the metalworking fluid circuit shall ensure that sufficient metalworking fluid is available at the machining point at any time.

Starting of the wheel spindle shall be prevented if the metalworking fluid supply is not properly functioning.

In MSO 1, the machining process shall be stopped in an adequate way if the metalworking fluid supply is insufficient.



Key

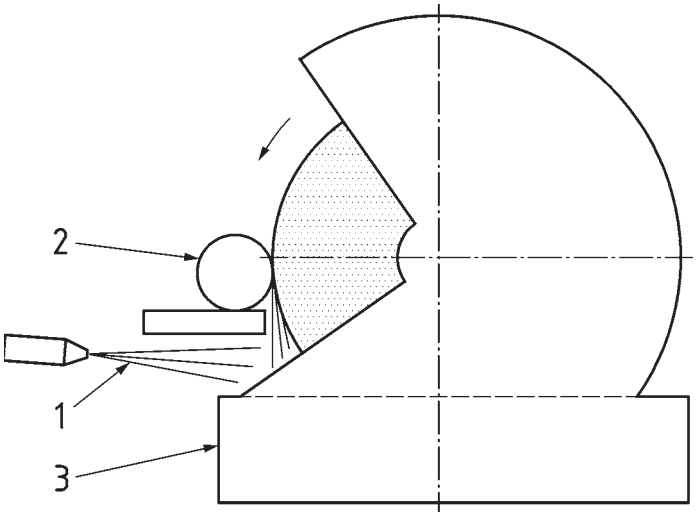
1 metalworking fluid
2 workpiece
3 collecting basin

Figure G.1 — Wet grinding process

G.2 Devices for dry grinding with wet precipitation by means of instantaneous moistening

The machine shall be equipped with devices for the moistening of the generated dust with water or other suitable metalworking fluids directly behind the grinding point so that the dust is bound, precipitated and collected there. The dimensioning of the water or metalworking fluid circuit shall ensure that a sufficient quantity of fluid is available at any time for the wet precipitation.

Starting of the wheel spindle shall be prevented if the metalworking fluid supply is not properly functioning.



Key

1 metalworking fluid
2 workpiece
3 collecting basin

Figure G.2 — Dry grinding with wet precipitation by instantaneous moistening

G.3 Equipment for dry grinding with precipitation by means of a wet-type collecting system

The machine shall be equipped with devices for the extraction of the generated dry grinding dust directly at the machining point and with a suitable system for the wet precipitation of the extracted dust.

The machining area of the machine shall be designed and constructed so that dust accumulations are prevented.

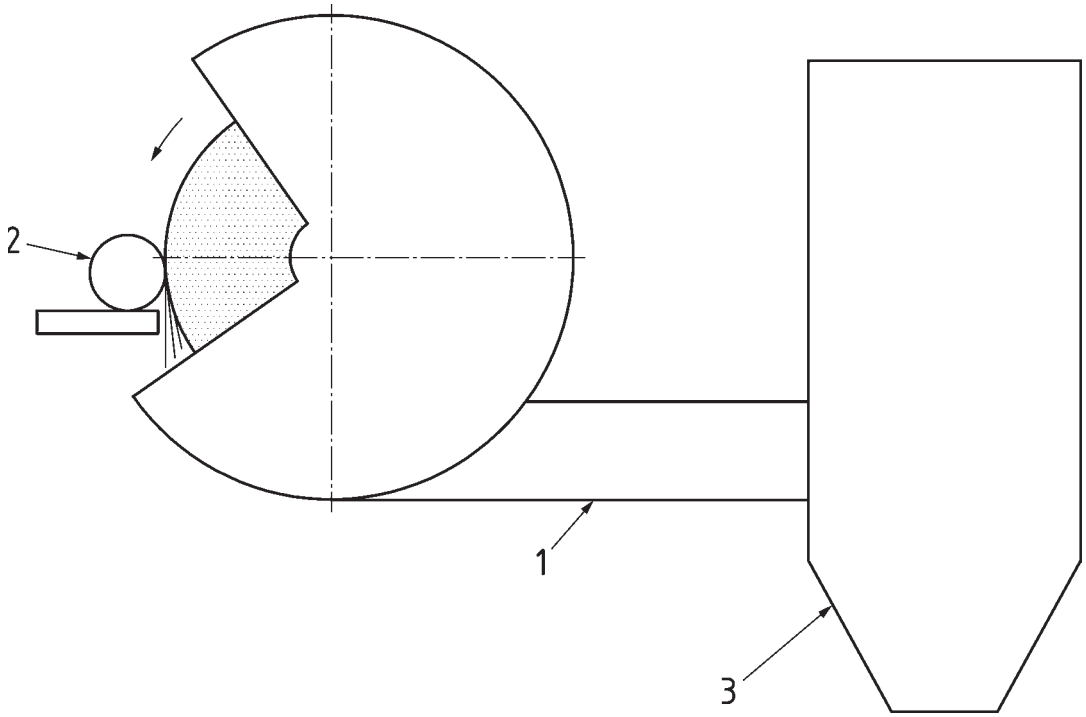
The wet-type collecting system shall ensure sufficient moistening of dust with the washing water. Dust caking and accumulation inside the collecting system shall be prevented. Accumulation of dangerous hydrogen/air mixtures shall be prevented even if the collecting system is at standstill.

Starting of the wheel spindle shall be prevented if the extraction or the wet precipitation is not properly functioning.

The machining process shall be stopped in an adequate way if the extraction and precipitation are insufficient.

During construction of the extraction devices, an air velocity of 20 m/s shall be taken as basis for a safe capture and transport of grinding dust.

Extraction fans shall be placed at the clean air side and shall continue to work after the stop of the grinding machine as long as necessary to avoid sedimentation of the grinding dust in the pipework.



Key

1 extraction
2 workpiece
3 wet-type collecting system

Figure G.3 — Dry grinding with wet precipitation of the grinding dust

Annex H
(informative)

Measures for the use of flammable metalworking fluids

H.1 Selection of low-emission metalworking fluids

Metalworking fluids containing more than 15 % of oil can result in fire or deflagration hazards.

Through selection of low-emission metalworking fluids non-soluble in water, the formation of aerosols and vapours in the interior of the machine can be reduced. Low-emission metalworking fluids are characterized by the following properties:

— preparation on the basis of low-vapour mineral oils or synthetic esters and/or special fluids;

— addition of anti-mist additives.

In Table H.1, recommended characteristics for the selection of low-emission metalworking fluids as a function of viscosity classes and of the machining process are given.

Table H.1 — Characteristics of non-water soluble metalworking fluids

Tendency	Viscosity class acc. to ISO 3448:1992	Viscosity at 40 °C in mm^2/s	Flash point to ISO 2592 (Cleveland open cup method) in °C	Vaporization loss at 250 °C (Noack method) in %	Machining process (Examples)
Decreasing fire and explosion hazard ↓	ISO VG 5	4,14 - 5,06	>120	<85	honing, chafing
	ISO VG 7	6,12 - 7,48	>145	<80	grinding
	ISO VG 10	9 - 11	>155	<60	deep drilling
	ISO VG 15	13,5 - 16,5	>190	<25	turning, milling
	ISO VG 22	19,8 - 24,2	>200	<15	drilling
	ISO VG 32	28,8 - 35,2	>210	<13	threading
	ISO VG 46	41,4 - 50,6	>220	<11	thread rolling broaching

In principle, it is recommended to select the metalworking fluid with the lowest vaporization loss and the highest flash point at the viscosity required by the machining process, which should be as high as possible.

H.2 Flame-proof labyrinth seals

The egress of flames into the operating area can almost be completely prevented by the use of suitable labyrinth seals at doors of machine tools. Labyrinth seals with several changes of direction of the flame path and maximum gap widths of ≤2 mm have delivered the best results.

Construction principles of flame-proof labyrinths:

— gaps narrowing in case of sudden increase of pressure in the machine interior space;

— gap width at the narrow points 2 mm at maximum;

— change of flow direction at least 2 × 180°;

— adjustability of gaps;

— no use of flammable materials;

— direction of outlet not directly towards the operator;

— protection of shearing and crushing points by appropriate means (e.g. edge protection).

The labyrinth seal shown in Figure H.1 functions on the principle of multiple direction changes connected in series and expansions of the entering flames.

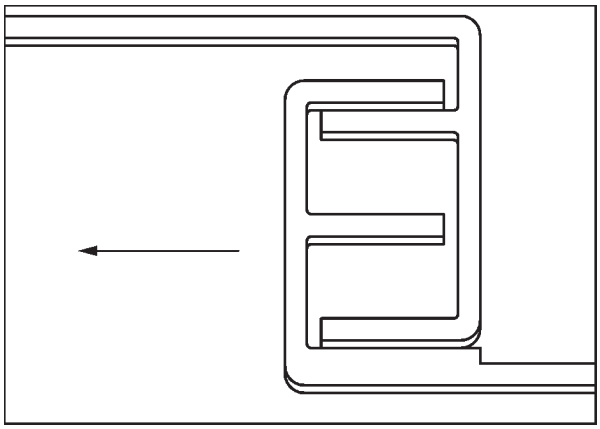
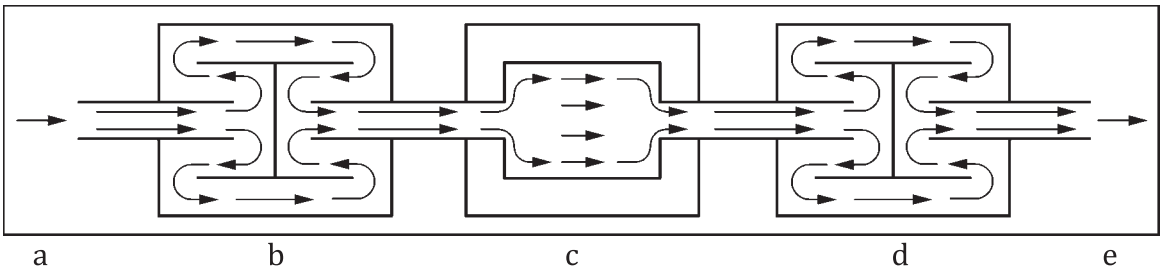


Figure H.1 — Principle scheme of a flame-proof labyrinth seal

H.3 Prevention of ingress of flames into the extraction system

The use of a baffle plate in front of the extraction opening in combination with a suitable flame arrester in the extraction path can prevent flame propagation into the (central) extraction system.

The flame arrester shown in Figure H.2 functions on the principle of multiple direction changes and expansion of the entering flames.



Key

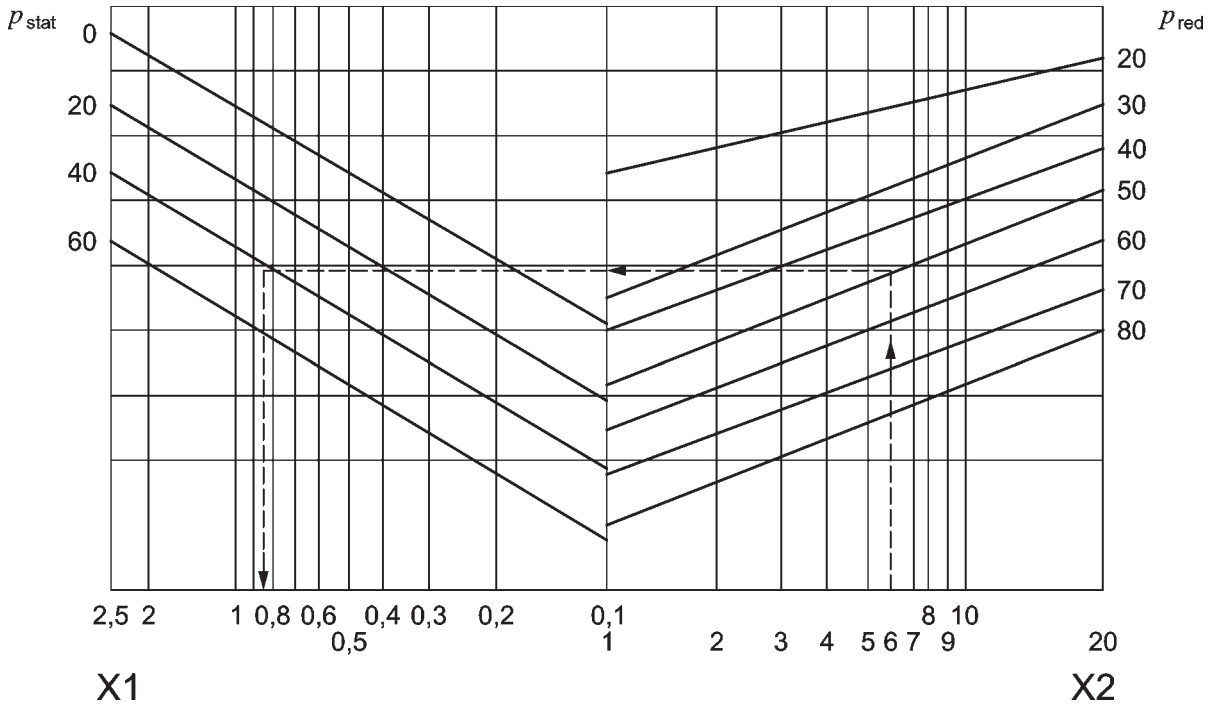
a supply air
b direction changes
c expansion
d direction changes
e exhaust air

Figure H.2 — Principle scheme of a flame arrestor in the extraction path

H.4 Dimensioning of pressure relief surfaces

Depending on the pressure resistance of the work zone enclosure, the integration of a pressure relief device can be necessary to limit the explosion pressure to a non-hazardous extent and to direct escaping flames into a non-hazardous direction (e.g. pressure relief device on the machine top).

The necessity of a pressure relief device and the size of the pressure relief surface can be determined by means of Figure H.3. For this purpose, the volume of the work zone enclosure is entered in the right section. From the intersection with the line representing the maximum reduced explosion pressure p_{red} in the work zone enclosure, a horizontal line is followed up to the intersection with the line representing the static response pressure p_{stat} of the selected pressure relief device. The relief surface required can then be seen on the x-axis. Natural housing openings, e.g. supply air openings, can be taken into account under the assumption of a static response pressure of 0 mbar.



Key

p_{stat} static response pressure, in mbar

p_{red} maximum reduced explosion pressure, in mbar

X1 relief surface, in m^2

X2 volume of the work zone enclosure, in m^3

NOTE Figure H.3 is valid for a degree of filling of 5 %.

Figure H.3 — Explosion pressure relief - Nomogram for estimation of the surface required

Annex I
(informative)

Examples for the integration of extraction and fire extinguishing systems when using flammable metalworking fluids

Monitoring of metalworking fluid supply and extraction system is essential to the safe functioning of the machine.

The safety measures after fire detection depend on the type of extraction system (central or local):

a) For a central automatic extraction system

   1) immediate stop of the machining processes (with or without controlled tool retraction);

   2) suppression of flame penetration into the extraction system by means of a closing flap or valve shutter device (exhaust air valve); penetration of ignition particles into the pipes of the extraction system cannot be prevented;

   3) immediate initiation of the extinguishing process;

   4) stop of metalworking fluid supply;

   5) possibility of continued operation of the central extraction system.

b) For local extraction system (usually on top of the machine)

   1) immediate stop of the machining processes (with or without controlled tool retraction);

   2) stop of local extraction system;

   3) immediate initiation of the extinguishing process;

   4) stop of metalworking fluid supply.

In order to implement the above safety functions, the controls of the grinding machine, the extraction system and the extinguishing system need to have appropriate interfaces (see Figure I.1).

NOTE 1 If an automatic fire extinguishing system is required at the grinding machine, Figure I.1 shows an example of the interaction of the control systems of grinding machine and fire extinguishing system.

NOTE 2 These safety measures for fire prevention and protection are not sufficient for machining flammable materials such as magnesium or titanium. For this type of material, special measures shall be applied.

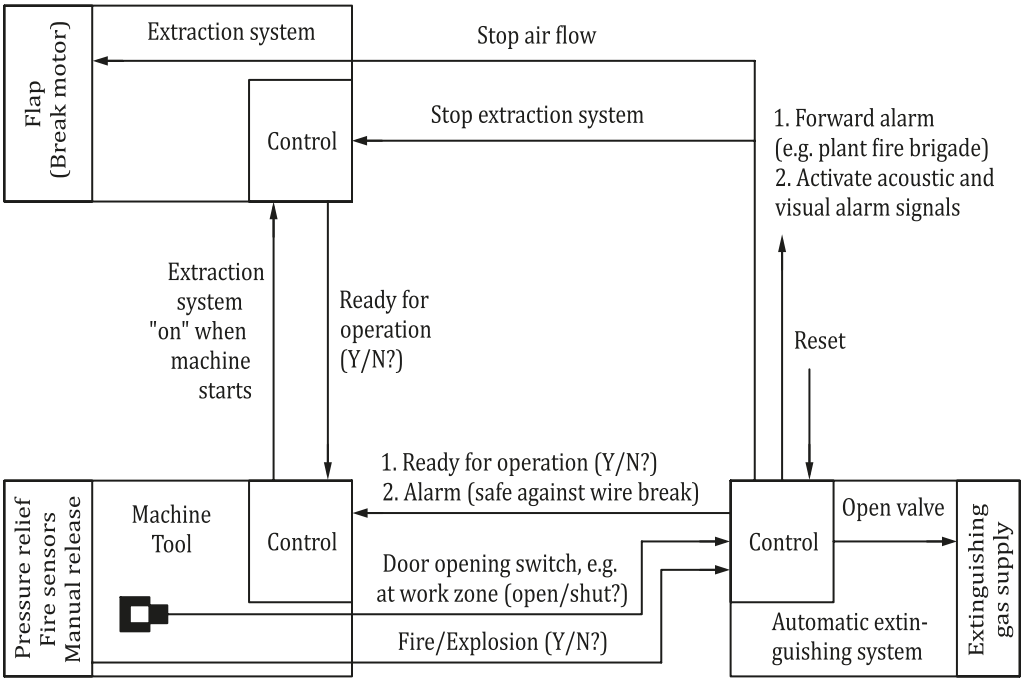


Figure I.1 — Example of the interaction between the grinding machine control and the control of a fire extinguishing system

Annex J
(informative)

Functional safety — Example for rotational speed limit monitoring of the wheel spindle

J.1 General

In 5.12 b) 5), the requirements PLr = d and category 3 are specified. With more thorough consideration, it becomes obvious that three individual safety functions have to be defined in order to verify compliance with the above requirements. This will result in three individual quantifications.

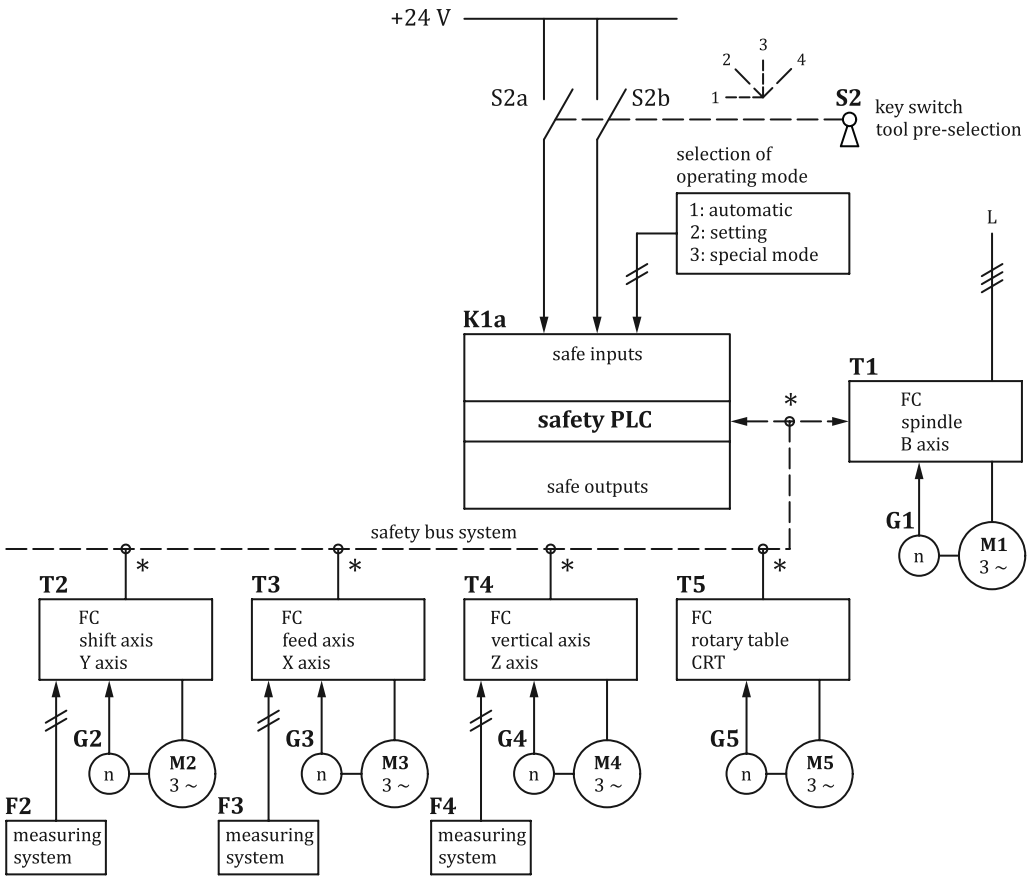
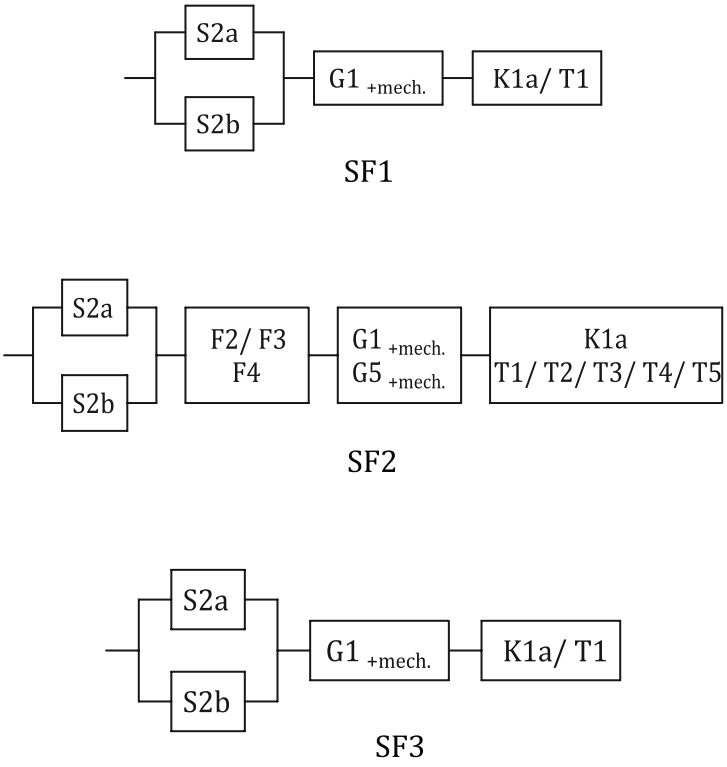


Figure J.1 — Example of basic electric wiring diagram

J.2 Safety functions

Safety PLC (K1a) and FC T_n are a combined technical unit. Two-channel condition is reached by combination of the safety PLC (K1a) with one FC T_n at a time. Among others, the safety functions STO, SLS safe cams are integrated, for each of which the control system manufacturer indicates PL, category and PFH.



Key

SF1 limitation of the rotational speed of the wheel spindle

SF2 limitation of the peripheral speed of the abrasive product (SUG) for decreasing abrasive product diameter[a]

SF3 limitation of the maximum SUG[b] as a function of the selected tool

[a] Dressing tool in dressing position monitored by safe cam.

[b] SUG: Peripheral sped of the abrasive product.

Figure J.2 — Example of safety-related block diagrams

J.3 Calculation of the probability of failure

a) For all safety functions: Sufficient measures against common cause failures (CCF) at least 65 points: Separation (15), protection against over-voltage etc. (15) and environmental conditions (25+10).

b) Actuation of the tool pre-selection switch S2 shall not initiate a movement. The pre-selection switch has fourfold coding and is read into the safety PLC via two channels.

c) The $B10_d$ value for the pre-selection switch is 10^6 switching cycles[1)]. For an operating cycle of every 4 h on 240 days over 16 h, n_{op} = 960 cycles/year and $MTTF_d$ = 10 416 years result for an electromagnetic contact (e.g. S2a). With a DC = 99 % by plausibility check, the PFH for the subsystem of the tool pre-selection switch S2 is $2{,}47 \times 10^{-9}$/h.

d) For the mechanical axes (including bearing) $G1_{mech}$ and $G5_{mech}$ between motor and encoder, fault exclusion is assumed. The manufacturer shall provide verification of fatigue strength (see as well IEC 61800-5-2:2007-07, Table D.19).

e) For the rotary shaft encoders G1 and G5, PFH = $2{,}6 \times 10^{-9}$ and category 3[1)] are stated by the manufacturer.

1) B_{10d} or $MTTF_d$ values on the basis of manufacturer's data.

f) The linear measuring systems F2 - F4 have an FIT value of 1500 h[1)] corresponding to an $MTTF_d$ value of about 152 years. The DC is assumed to be 90 %, as the linear measuring system is integrated into the control circuit and average fault detection is given by the safety PLC K1a.

g) The safety control K1a and the safe I/O modules are tested safety components of category 3. The probability of failure results in a PFH of $2{,}89 \times 10^{-7}$/h[1)].

h) The frequency converters T1 - T5 are control modules with a PFH of $4{,}8 \times 10^{-9}$/h[1)] each. The frequency converters dispose of integrated safety functions which are used for the control of the movement of axes and spindles (e.g. SOS, SLS, SS1).

i) For the calculation of the subsystem K1a/T1 (see SF1 and SF3), the method given by the manufacturer was used. It resulted in a total PFH for the subsystem of $3{,}34 \times 10^{-7}$/h.

j) For the calculation of the subsystem K1a/T1/T2/T3/T4/T5 (see SF2), the method given by the manufacturer was used. It resulted in a total PFH for the subsystems of $5{,}14 \times 10^{-7}$/h.

k) For SF1, the calculated PL = d and PFH = $3{,}84 \times 10^{-7}$/h.

l) For SF2, the calculated PL = d and the PFH = $9{,}32 \times 10^{-7}$/h.

m) For SF3, the calculated PL = d and the PFH = $3{,}84 \times 10^{-7}$/h.

Annex K
(informative)

MSO 3 (Optional special mode for manual intervention under restricted operating conditions) – Examples

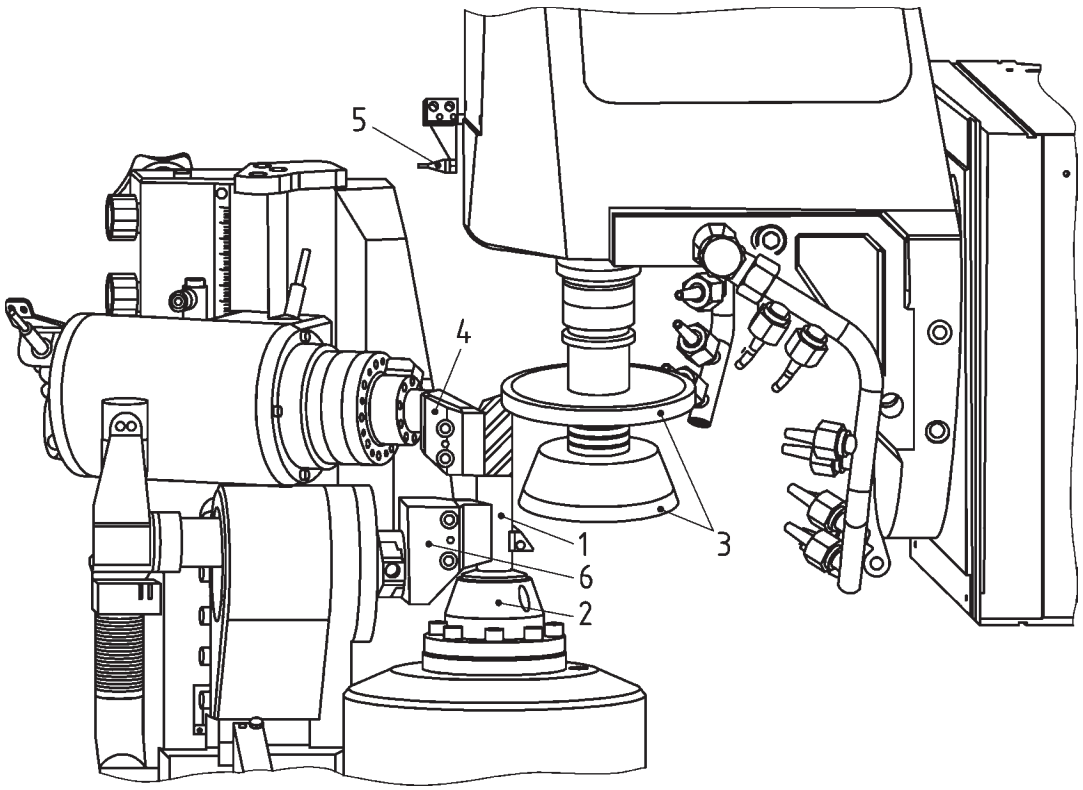
K.1 General

5.2.7.5 describes fundamental safety requirements in order to allow the performance of automatic program runs while guards are open. As applications are very different, complete protective measures can only be described by means of an example. When using MSO 3 for other applications, the safety level given in the example should at least be obtained.

K.2 Example 1: Control of a new NC Program run during setting operation

K.2.1 Situation

A CNC controlled tool grinding machine for automatic processing of milling tools is being set up. In addition to the grinding spindle, on which up to three grinding tools can be mounted, there is a measuring sensor in the working space. Furthermore, additional equipment to support the workpiece is used. For proving out a newly written program is to be started for the first time at a workpiece. An offset of approximately 5 mm is set between the workpiece and the tool. During first program run, the setter is to control the movements of the grinding tool and ensure that the moving axes do not collide. Due to the complex workpiece geometry, he should be able to evaluate the whole program run from different perspectives. Because of these different perspectives, the use of a camera system will not be possible (see Figure K.1).



Key

1 workpiece (end mill)
2 chuck
3 grinding wheel set
4 back rest
5 measuring sensor
6 channel support

Figure K.1 — Tool grinding machine

During the program run, the setter can reduce the speeds of the axes by means of an actuator until standstill. The coolant is shut off during setting operations. The abrasive product is to turn at 500 min^{-1} (<16 m/s) in order to ensure concentric runout of the spindle. Processing of the workpiece is not necessary.

K.2.2 Implementation of safety requirements

In order to set the machine with automatic movements while the guards are open, MSO 3 is to be selected by means of a separate mode selector (key switch).

The abrasive product is to turn at 500 min^{-1} (<16 m/s) in order to ensure concentric runout of the spindle. Hence, risk by contact with the abrasive product is reduced to tolerable risk level.

To prevent hazards by axis movements, the axes are to be initially at a safe stop or safe operational stop when MSO 3 is selected and guards are open. Only when the enabling device is actuated, the axes are switched from safe stop/safe operational stop to a state that movement is permitted with reduced speed (<2m/min).

Automatic movements of the axes, as well as workpiece spindle rotation (<50 min^{-1}), are started by actuating the start button together with the enabling device. While one hand is on the enabling button, the other hand turns the actuator for the manual override. Consequently, both hands are bound and are outside the hazard zone.

By means of the manual override, the speed of the axis can continuously be set from 0 m/min (standstill) up to 2 m/min.

To prevent falling down into the machine, the lower border of the opening for the operator exceeds 1100 mm, according to ISO 13857.

Hazards by hazardous substances or fire hazards by coolant mists are not present because coolant supply is not necessary and therefore shut off.

The noise level is below 75 dB(A) because no processing takes place. Concerning electrical, biological, thermal, and ergonomic hazards, as well as hazards by vibration, energy supply failure, radiation, overspeed, or control failure, the requirements given in Clause 5 apply.

K.3 Example 2: Positioning of a profile rail on movable workpiece table and dressing of profiled grinding wheel

K.3.1 Situation

A closed CNC surface grinding machine requires MSO 3. This surface grinding machine is to be used to perform automatic grinding of profile rails (see Figure K.2 and Figure K.3).

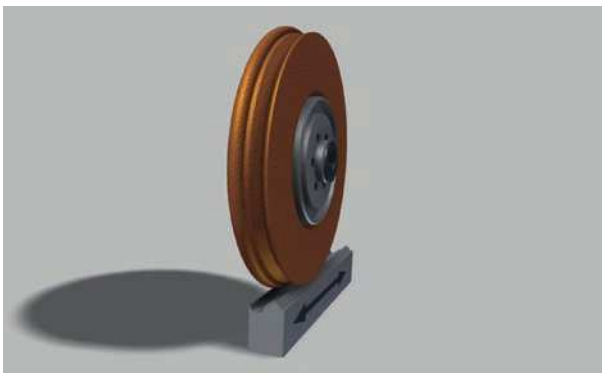


Figure K.2 — Profile grinding

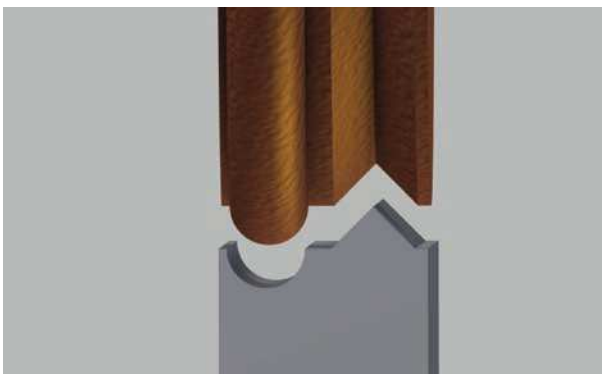


Figure K.3 — Profile grinding

Prior to starting the grinding process itself, the component, i.e. the roughened profile rail, is to be aligned exactly on the movable workpiece table. This kind of operation is also called “threading”. For this purpose, the workpiece table must perform an automatic oscillation in order to travel along the whole length of the rail and to enable a checking of the correct positioning of the workpiece. It is not possible to observe the contour edge between profile rail and grinding wheel through the vision panel of the closed guard because it is not visible from the operator’s position. That is why the operator has to hear when he is grinding the profile during oscillation whether the grinding wheel is uniformly

engaged on all sides. This process is very difficult and requires a lot of exercise, in particular when the profile rail has a plastic coating which only produces scarcely audible sound during the grinding operation. When the operator hears that no uniform engagement over the whole length of the profile rail is performed, the automatic oscillation of the axis is stopped with the override and the position of the profile rail is corrected by the operator.

Then there is another process on the machine where automatic movements of the axis with guards open require MSO 3. This process is the precise dressing of the profiled grinding wheel contour (see Figure K.4 and Figure K.5).

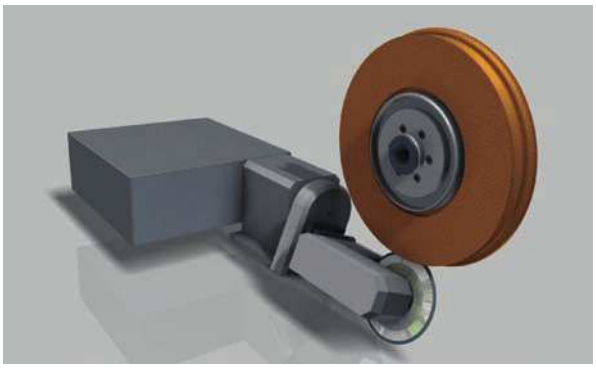


Figure K.4 — Pivoting dressing tool

Figure K.5 — Pivoting dressing tool

Dressing is made by means of programmed automatic movements of the pivoting arm dressing tool. During the movements, the operator is to check whether the programmed target contour corresponds to the actual contour of the abrasive wheel. He makes this by listening to the changes in the sound images during the dressing operation.

K.3.2 Implementation of safety requirement

To enable the required automatic movements of the pivoting arm dressing tool and of the workpiece table with guards open, MSO 3 is selected via a separate operating mode selector switch (key switch). Where MSO 3 under guard open condition is selected, the axes are at safe stop or safe operational stop. Only after pressing the start button, the automatic travel movements are started under guard closed. The guard is held in a closed position during programmed cycle. When the enabling device is activated and the speeds are reduced to safe limited speed, opening of the guard is possible. Thus, hazards caused by axis movements are sufficiently reduced.

The abrasive wheel can turn with a peripheral speed with a maximum of 16 m/s. Rotational speed of an electroplated diamond roller dresser has a maximum of 2 400 min-1. With a diameter of 125 mm, this corresponds to a peripheral speed of nearly 16 m/s. So there will be reduced risk given by touching the grinding wheel or by fracture parts in case of a bursting abrasive wheel.

When the guard is open, the axes are held by actuating the enabling device from safe stop/operational stop in a movement with safely reduced speeds of <2m/min for the pivoting arm dressing tool, and of <5 m/min for the oscillating axle of the workpiece table (travelling distance >1 m). When the enabling device is not actuated or when the button is released or pushed through, an immediate safe stop/operational stop will follow.

While one hand is on the enabling button, the second hand actuates the control for the override or also the electric hand wheel. Hence, both hands are bound and cannot have access to the danger zone.

The oscillating speed of the workpiece table or the axle speed of the pivoting arm dressing tool can be steplessly varied with the override, however to not more than a safely reduced speed.

One individual axis can be travelled (fine adjustment), superior to the process, by means of the electric hand wheel.

Hazards given by the cooling lubricant are reduced as far as possible by limiting the supply of cooling lubricants to the absolutely required minimum quantity. Small quantities of cooling lubricants are necessary to avoid eventually occurring burning, when travelling by accident into the material during setting. Where the cooling lubricant which cannot be avoided splashes into the left-side closed area of the machine, extraction also takes place. Contact of the operator with the cooling lubricant or with cooling lubricant mist is more than unlikely.

Due to reduced speed and the small material removal, the sound level is less than 70 dB(A). As far as electrical, biological, thermal, and ergonomic hazards are concerned, as well as hazards by vibrations, breakdown on energy supply, radiation, overspeed, or control related failure, the requirements specified in Clause 5 apply.

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