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Machine tools — Safety — Turning machines
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Werkzeugmaschinen - Sicherheit - Drehmaschinen (ISO 23125:2015)

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Foreword

This document (EN ISO 23125:2015) has been prepared by Technical Committee ISO/TC 39 “Machine tools” in collaboration with Technical Committee CEN/TC 143 “Machine tools - Safety” the secretariat of which is held by SNV.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2015, and conflicting national standards shall be withdrawn at the latest by July 2015.

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This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Endorsement notice

The text of ISO 23125:2015 has been approved by CEN as EN ISO 23125:2015 without any modification.

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 98/37/EC

This European Standard has been prepared under a mandate given to CEN [CEN/CENELEC/ETSI] by the European Commission [and] the European Free Trade Association to provide one means of conforming to Essential Requirements of the New Approach Directive 98/37/EC.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the normative clauses of this standard confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

WARNING — Other requirements and other EU Directives may be applicable to the products falling within the scope of this standard.

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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. www.iso.org/directives

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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 ISO/TC 39, *machine tools*, Subcommittee SC 10, *Safety*.

This second edition cancels and replaces the first edition (ISO 23125:2010), of which it constitutes a minor revision. It also incorporates the Amendment ISO 23125:2010/Amd1:2012.

The International Standards produced by ISO/TC 39/SC 10 in collaboration with CEN/TC 143 are particular to machine tools and complement the relevant A and B standards on the subject of general safety (see Introduction to ISO 12100 for a description of type-A, -B and -C standards).

This International Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

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Introduction

This International Standard has been prepared to be a Harmonized Standard to provide one means of conforming to the Essential Safety Requirements of the Machinery Directive of the European Union and associated EFTA regulations.

This International Standard is a type-C standard as defined in ISO 12100:2010.

The machinery concerned and the extent to which hazards, hazardous situations and events are covered is indicated in the Scope of this International Standard. In addition, turning machines shall comply as appropriate with ISO 12100:2010 for hazards which are not covered by this International Standard.

When provisions of this type-C standard are different from those which are stated in type-A or -B standards, the provisions of this type-C standard take precedence over the provisions of the other International Standards for machines that have been designed and built in accordance with the provisions of this type-C standard.

This International Standard makes reference to the “safety categories” in EN 954-1:1996 as resistance to faults and their subsequent behaviour in the fault condition together with the “performance level” defined in ISO 13849-1:2006 in terms of probability of dangerous failure per hour. It is the decision of the user of this International Standard to apply “safety categories” or “performance levels”.

The requirements of this International Standard concern designers, manufacturers, suppliers and importers of machines described in the Scope.

This International Standard also includes a list of informative items to be provided by the manufacturer to the user.

The requirements for a new mode of operation, Mode 3 “manual intervention machining mode” will be discussed in the future.

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Machine tools — Safety — Turning 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 turning machines and turning centres, which are designed primarily to shape metal by cutting.

— **Group 1**: Manually controlled turning machines without numerical control.

— **Group 2**: Manually controlled turning machines with limited numerically controlled capability.

— **Group 3**: Numerically controlled turning machines and turning centres.

— **Group 4**: Single- or multi-spindle automatic turning machines.

NOTE 1 For detailed information on the machine groups, see the definitions in 3.4 and mandatory and optional modes of operation in 3.3.

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

NOTE 3 Hazards arising from other metalworking processes (e.g. grinding and laser processing) are covered by other International Standards (see Bibliography).

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

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

This International Standard also includes 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 processes (milling, grinding, etc.) are involved, this International Standard can be taken as a basis for safety requirements; for specific information see the Bibliography.

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

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable to 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 230-5:2000, *Test code for machine tools — Part 5: Determination of the noise emission*

ISO 447:1984, *Machine tools — Direction of operation of controls*

ISO 702 (all parts), *Machine tools — Connecting dimensions of spindle noses and work holding chucks*

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ISO 841:2001, *Industrial automation systems and integration — Numerical control of machines — Coordinate system and motion nomenclature*

ISO 3744:2010, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for an essentially free field over a reflecting plane*

ISO 3746:2010, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Survey method using an enveloping measurement surface over a reflecting plane*

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 4871:1996, *Acoustics — Declaration and verification of noise emission values of machinery and equipment*

ISO 6385:2004, *Ergonomic principles in the design of work systems*

ISO 8525:2008, *Airborne noise emitted by machine tools — Operating conditions for metal-cutting machines*

ISO 9241 (all parts), *Ergonomics of human-system interaction*

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 10218-2:2011, *Robots and robotic devices — Safety requirements for industrial robots — Part 2: Robot systems and integration*

ISO 11161:2007+Amd.1:2010, *Safety of machinery — Integrated manufacturing systems — Basic requirements*

ISO 11202:2010, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions applying approximate environmental corrections*

ISO 11204:2010, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions applying accurate environmental corrections*

ISO 11228 (all parts), *Ergonomics — Manual handling*

ISO/TR 11688-1:1995, *Acoustics — Recommended practice for the design of low-noise machinery and equipment — Part 1: Planning*

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 13849-2:2003, *Safety of machinery — Safety-related parts of control systems — Part 2: Validation*

ISO 13850:2006, *Safety of machinery — Emergency stop — Principles for design*

ISO 13851:2002, *Safety of machinery — Two-hand control devices — Functional aspects and design principles*

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ISO 13854:1996, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body*

ISO 13855:2010, *Safety of machinery — Positioning of safeguards with respect to the approach speeds of parts of the human body*

ISO 13856-2:2005, *Safety of machinery — Pressure-sensitive protective devices — Part 2: General principles for the design and testing of pressure-sensitive edges and pressure-sensitive bars*

ISO 13856-3:2013, *Safety of machinery — Pressure-sensitive protective devices — Part 3: General principles for design and testing of pressure-sensitive bumpers, plates, wires and similar devices*

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 14119:2013, *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 14122-1:2001, *Safety of machinery — Permanent means of access to machinery — Part 1: Choice of fixed means of access between two levels*

ISO 14122-2:2001, *Safety of machinery — Permanent means of access to machinery — Part 2: Working platforms and walkways*

ISO 14122-3:2001, *Safety of machinery — Permanent means of access to machinery — Part 3: Stairs, stepladders and guard-rails*

ISO 14122-4:2004, *Safety of machinery — Permanent means of access to machinery — Part 4: Fixed ladders*

ISO 14159:2002, *Safety of machinery — Hygiene requirements for the design of machinery*

ISO 15534-1:2000, *Ergonomic design for the safety of machinery — Part 1: Principles for determining the dimensions required for openings for whole-body access into machinery*

ISO 15534-2:2000, *Ergonomic design for the safety of machinery — Part 2: Principles for determining the dimensions required for access openings*

ISO 16156:2004, *Machine-tools safety — Safety requirements for the design and construction of work holding chucks*

IEC 60204-1:2009, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

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

IEC 60825-1:2007, *Safety of laser products — Part 1: Equipment classification and requirements*

IEC 61000-6-2:2005, *Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity for industrial environments*

IEC 61000-6-4:2011, *Electromagnetic compatibility (EMC) — Part 6-4: Generic standards — Emission standard for industrial environments*

IEC 61800-5-2:2007, *Adjustable speed electrical power drive systems — Part 5-2: Safety requirements — Functional*

EN 954-1:1996, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

EN 1837:1999+A1:2009, *Safety of machinery — Integral lighting of machines*

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3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100:2010, ISO 13849-1:2006 and EN 954-1:1996 and the following apply.

3.1 General terms

3.1.1
turning machine
machine tool in which the principal movement is the rotation of the workpiece against the stationary cutting tool(s)

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

3.1.3
manually controlled turning machine
turning machine (3.1.1) for which 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
computerized numerical control
CNC
automatic control of a process performed by a device that makes use of numerical data introduced while the operation is in progress

[SOURCE: ISO 2806:1994, 2.1.1]

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

3.1.6
turning centre
numerically controlled turning machine (3.1.5) equipped with power-driven tools and the capability to orientate the work holding spindle around its axis

Note 1 to entry: A turning centre can also include, but is not limited to, functions such as gauging, burnishing, threading, boring, milling, grinding and drilling.

Note 2 to entry: If grinding processes are involved, see EN 13218 for additional safety measures.

3.1.7
work zone
space where metal cutting is to take place

3.1.8
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]

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3.1.9
mean time to dangerous failure
$MTTF_d$
expectation of the mean time to dangerous failure

[SOURCE: ISO 13849-1:2006, 3.1.25]

3.1.10
category
classification of safety-related parts of a control system in respect of its resistance to fault and its subsequent behaviour in the fault condition, and which is achieved by the structural arrangement of the parts and/or their reliability

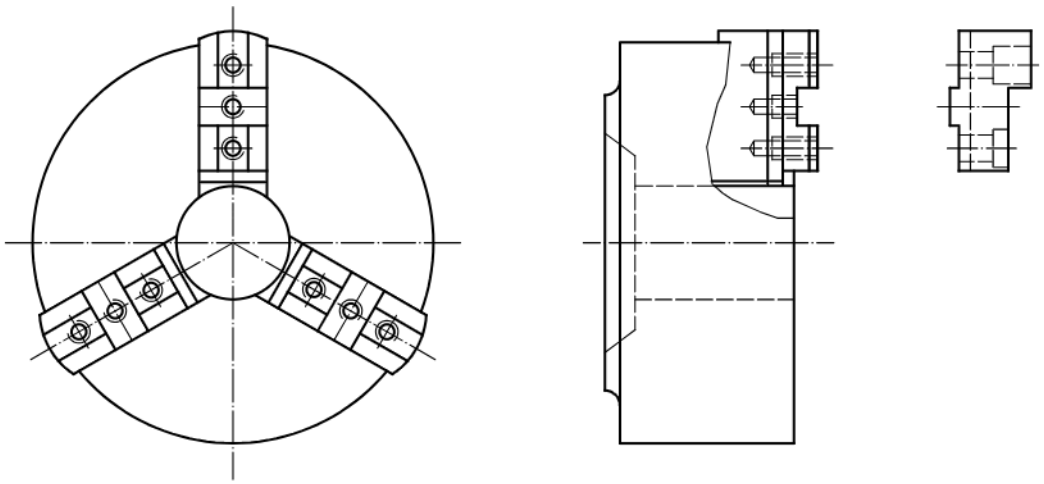
[SOURCE: EN 954-1:1996, 3.2.]

3.2 Terms related to parts of turning machines

3.2.1
vision panel
window provided in a guard through which the operator can view the *work zone* (3.1.7) or other areas of the machine

3.2.2
chuck
clamping device in which workpieces are clamped with the aid of either manual energy or pneumatic, hydraulic or electric energy

Note 1 to entry: See Figure 1.



NOTE The chuck with 3 jaws is an example only, a chuck can have 2, 3, 4 or 6 jaws.

Figure 1 — Chuck

3.2.3
collet
device designed to hold the bar into the turning spindle, e.g. by pressure bar or draw bar

Note 1 to entry: See Figure 2.

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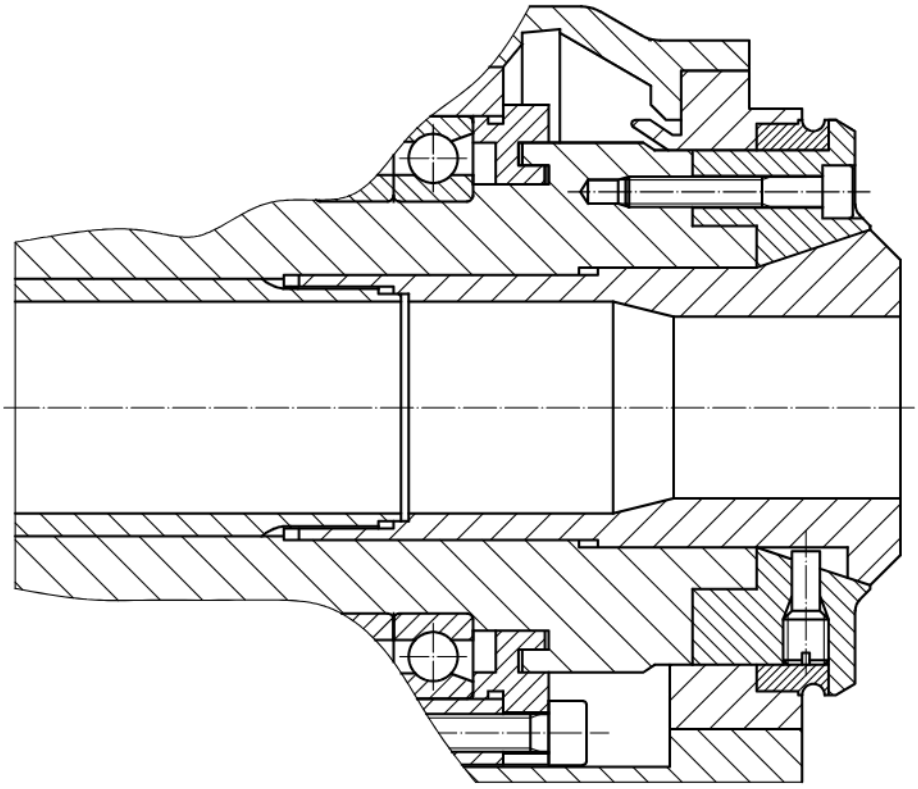


Figure 2 — Collet

3.2.4
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

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3.3 Terms related to modes of operation — Mandatory and optional modes of operation for turning machines

NOTE Table 1 gives an overview of the mandatory, optional or not allowed modes of operations for turning machines. Table 1 is mandatory.

Table 1 — Overview of turning machine groups and modes of operation

Mode of operation	Turning machines			
	Group 1 Manually controlled turning machines without numerical control	**Group 2** Manually controlled turning machines with limited capability of numerical control	**Group 3** Numerically controlled turning machines and turning centres	**Group 4** Single- or multi-spindle automatic turning machines
Mode 0 manual mode	Mandatory	Mandatory	Optional	Not allowed
Mode 1 automatic mode	Not allowed	Mandatory limited Mode 1	Mandatory	Mandatory
Mode 2[a] setting mode	Not allowed	Optional	Mandatory	Mandatory
Service mode[a]	Not allowed	Optional	Optional	Optional

[a] These modes are key protected and only available for well-trained and qualified staff (see 6.2.1). In order to allocate the access, it may be necessary to provide different key switches (or other appropriate access means) for a turning machine.

For example:

— Key 1: Access to setting mode (and automatic mode) for setting staff;

— Key 2: Access to CNC program code and CNC-parameter modifications to adequately trained staff [see 5.8 b) 2)];

— Key 3: Access to service mode for service staff.

NOTE In most applications, key switch 1 (setting mode) and key switch 2 (CNC program code access) can be identical.

3.3.1
Mode 0: manual mode
operation of the machine by the operator without NC functions or non-automatic mode of the machine axes, where the operator has control over the machining process without the use of pre-programmed operations

3.3.2
Mode 1: automatic mode
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
Mode 2: setting mode
mode of operation in which adjustments for the subsequent machining process are performed by the operator

Note 1 to entry: Checking of tool or workpiece position (e.g. by touching the workpiece with a probe or tool) are procedures of the setting mode (see 5.2.4.4).

3.3.4
service mode
mode for service and maintenance tasks, such as axis calibration by laser, ballbar testing and spindle error analysis

Note 1 to entry: In service mode, the machining of a workpiece is not allowed (see 5.2.4.5).

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3.4 Terms related to sizes and groups of turning machines defined

NOTE With regard to the relevant hazards, the turning machines are subdivided into four different groups. Group 1, Group 2 and Group 3 turning machines can then be subdivided into "small" or "large" sizes. See the overview in Table 2.

Table 2 — Overview of sizes and groups of turning machines

Group No.	Group name	Subclause in which group is defined	Subdivision in sizes	Subclause in which size is defined
Group 1	Manually controlled turning machines without numerical control	3.4.3	Small	3.4.1
			Large	3.4.2
Group 2	Manually controlled turning machines with limited numerically controlled capability	3.4.4	Small	3.4.1
			Large	3.4.2
Group 3	Numerically controlled turning machines and turning centres	3.4.5	Small	3.4.1
			Large	3.4.2
Group 4	Single- or multi-spindle automatic turning machines	3.4.6	No subdivision	—

3.4.1
small turning machine
turning machine within the following dimensional limits:

— horizontal spindle turning machines and turning centres with distance between centres (BC) up to and including 2 000 mm and which are designed to accept workpiece clamping devices of up to and including 500 mm outside diameter;

— vertical turning machines, inverted spindle turning machines including pick-up machines and turning centres, which are designed to accept workpiece clamping devices of up to and including 500 mm outside diameter

3.4.2
large turning machine
turning machine which exceeds the following dimensional limits:

— horizontal spindle turning machines and turning centres with distance between centres exceeding 2 000 mm or which are designed to accept work clamping devices exceeding 500 mm outside diameter;

— vertical turning machines, inverted spindle turning machines, including pick-up machines, and turning centres which are designed to accept work clamping devices exceeding 500 mm outside diameter

3.4.3
Group 1: manually controlled turning machine without numerical control
turning machine, where all movements are initiated and controlled by the operator, one at a time

Note 1 to entry: This group of turning machines may be equipped with the following features:

— mechanical facilities for mechanical feed or thread cutting;

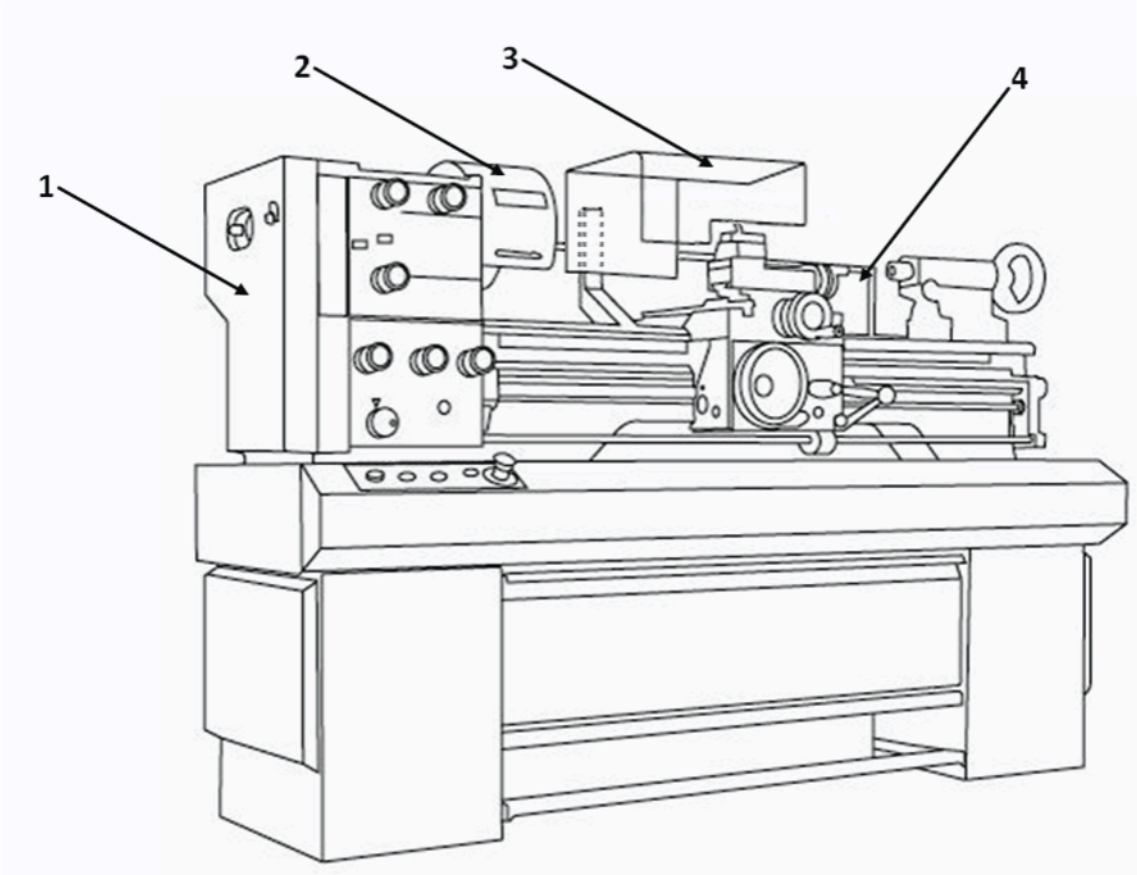
— electronic facilities for constant surface speed (CSS);

— copying attachments (cam, template, etc.);

— but shall have no limited or full numeric control system (NC).

For mandatory and optional modes of operation for this group of turning machines, see Table 1.

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Key

1	rear spindle end guard	3	front chip/splash guard (saddle mounted)
2	chuck guard	4	rear chip/splash guard

Figure 3 — Group 1: Example of a manually controlled, horizontal spindle turning machine

3.4.4
Group 2: manually controlled turning machine with limited numerically controlled capability
turning machine that can be operated as a Group 1 machine by the use of electronic handwheels or as a machine with limited NC control by operating controls on NC panel

Note 1 to entry: This group of turning machines may be equipped with some or all of the features of Group 1 turning machines (manual turning machines without NC) and the following:

— a limited numeric control system (NC) providing:

— constant surface speed (CSS);

— axis interpolation (i.e. copying/predefined profiling);

— thread cutting cycles.

However, the following features shall not be provided:

— automatic program start;

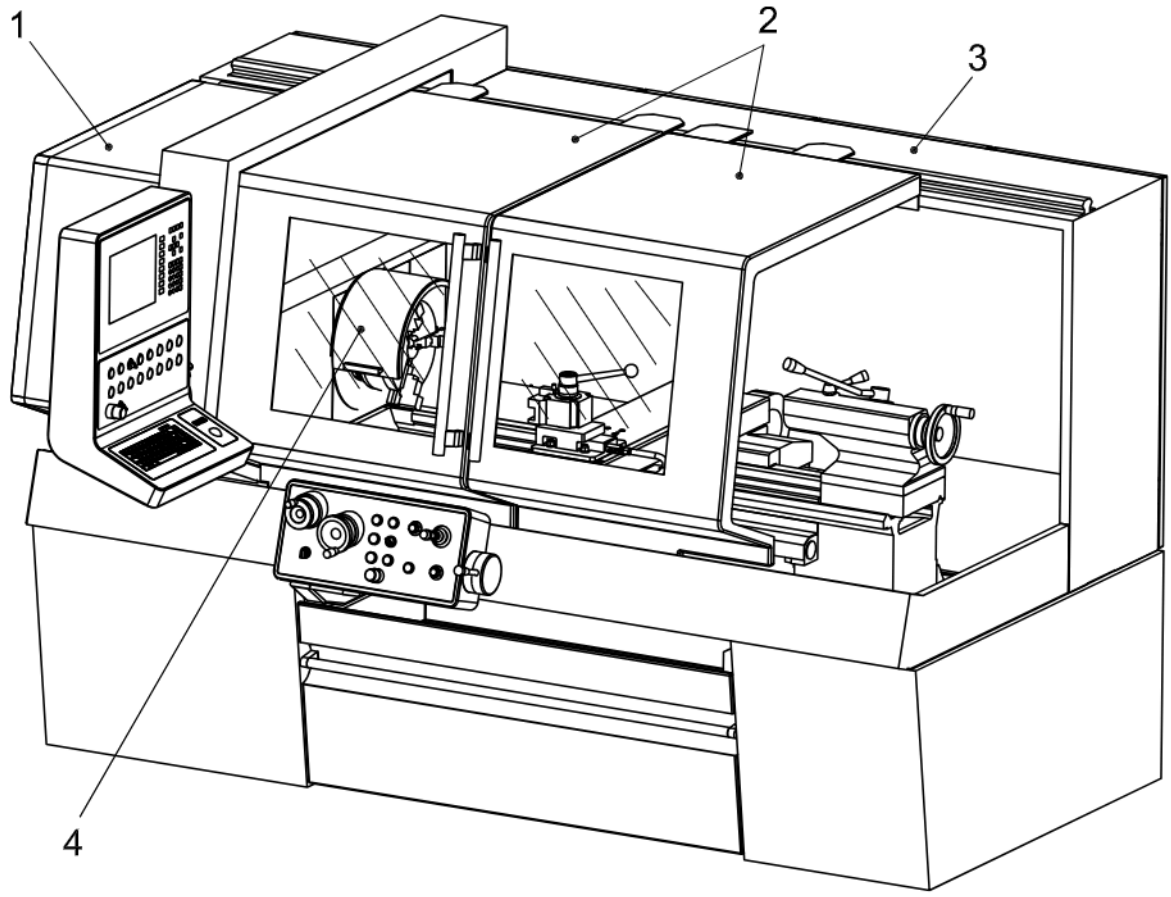
— automatic initiated tool change, turret indexing or tailstock quill advance or retract;

— unlimited rapid axis movements;

— automatic workpiece change or bar feed system.

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For mandatory and optional modes of operation for this group of turning machines, see Table 1.



Key

1	rear spindle guard	3	rear guard
2	front guard	4	chuck guard

NOTE The partial enclosure comprises 2 and 3.

Figure 4 — Group 2: Example of a manually controlled turning machine with limited NC capability

3.4.5
Group 3: numerically controlled turning machine and turning centre
turning machine with numerical control (NC) providing automatic function

Note 1 to entry: This group of turning machines may be equipped with some or all of the following features:

— a numeric control system (NC);

— automatic workpiece change or bar feed systems;

— automatic tool magazine, tool transfer and tool changing systems;

— automatic turret indexing or tailstock quill advance or retract;

— counter work holding spindle;

— double work holding spindle;

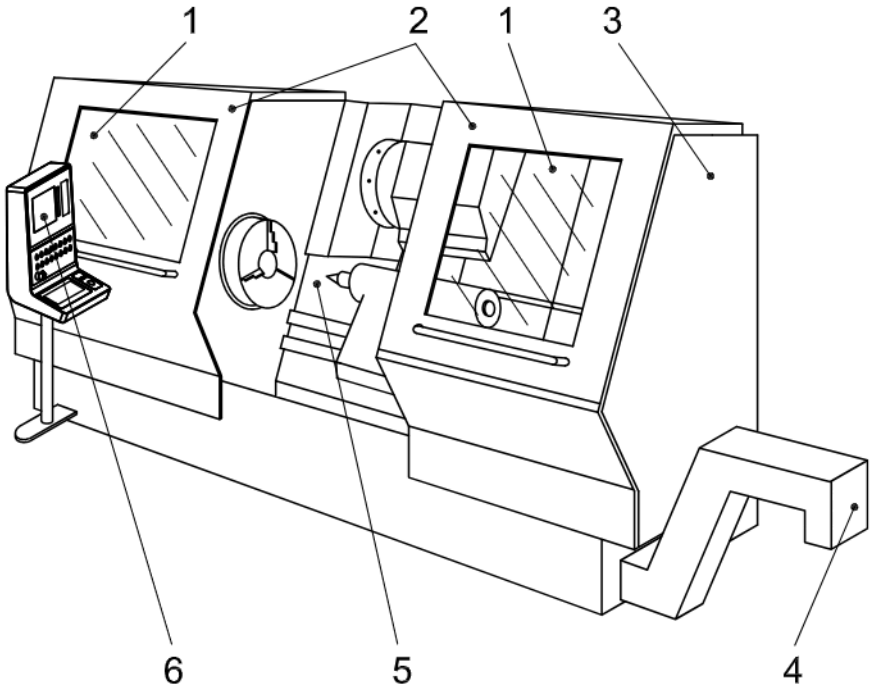
— secondary machining operations (e.g. milling, grinding, drilling);

— ancillary handling devices.

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However, it shall not be equipped with a rotating work holding spindle carrier, which moves the work holding spindle(s) from station to station.

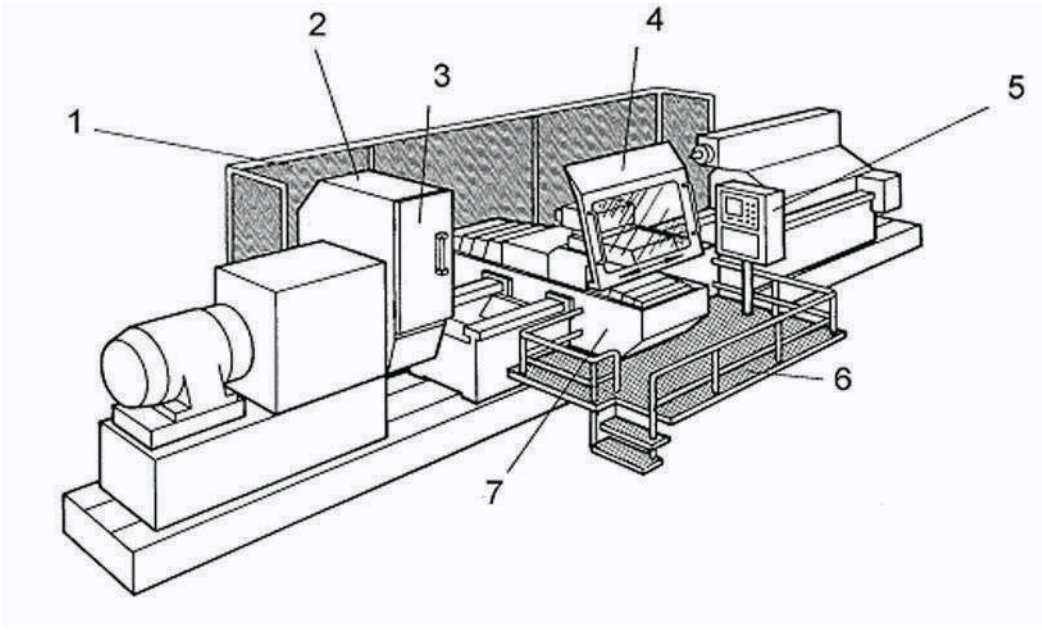
For mandatory and optional modes of operation for this group of turning machines, see Table 1.



Key

1	vision panel	4	chips conveyor
2	interlocked movable guards	5	work zone
3	enclosing guard	6	main control panel

Figure 5 — Group 3: Example of a small horizontal turning machine



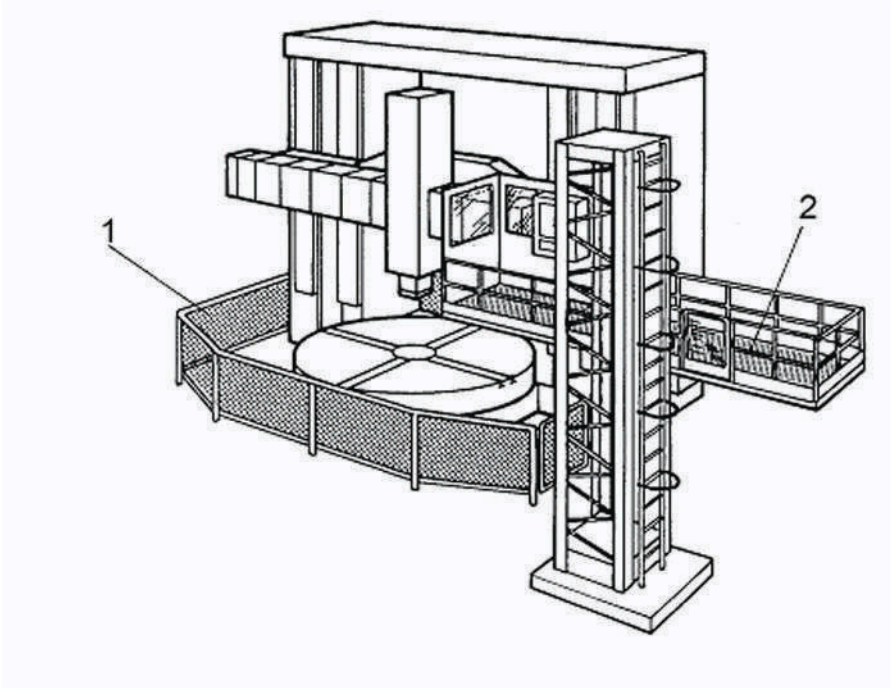
Key

1	rear guard	5	control panel
2	chuck guard	6	platform

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3 access door
4 front guard
7 saddle

Figure 6 — Group 3: Example of a large horizontal NC turning machine



Key
1 perimeter fence
2 platform

Figure 7 — Group 3: Example of a large vertical NC turning machine with operating platform

3.4.6
Group 4: single- or multi-spindle automatic turning machine

horizontal or vertical spindle turning machine, designed for batch production of parts according to an NC and/or mechanical (e.g. by cam or template) pre-set program with fixed sequence of operation

Note 1 to entry: This group of turning machines may be equipped with some or all of the following features:

— a spindle carrier holding two or more work holding spindles, equipped with either power-operated chucks or collets;

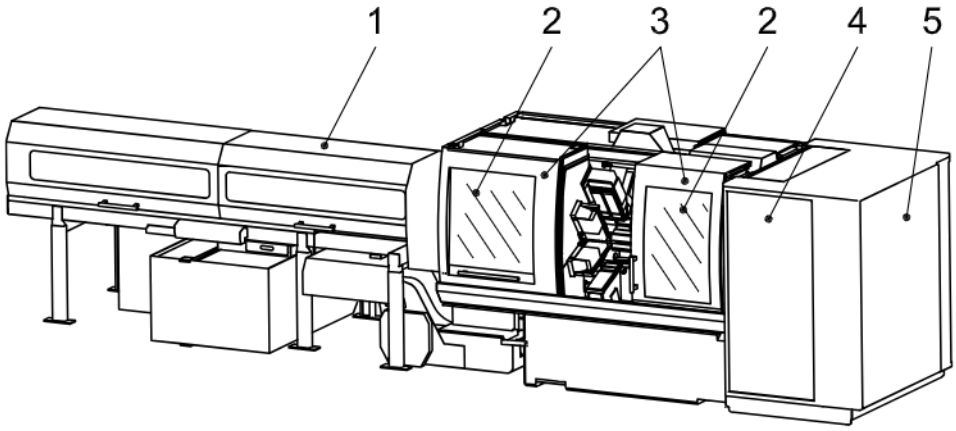
— additional features e.g. power-driven tools and one or more sub/counter spindles;

— the drives of the work holding spindles, tool spindles and sub/counter spindles may be by common and/or independent drives.

However, this group shall have no manually operated chucks.

For mandatory and optional modes of operation for this group of turning machines, see Table 1.

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Key

1 guarding of bar feeder
2 vision panel
3 interlocked movable guard
4 main control panel
5 enclosing guard

Figure 8 — Group 4: Example of a multi-spindle NC bar automatic turning machine with second carrier for counterspindles

3.5 Terms related to maximum permissible spindle speeds and axes feeds

3.5.1
maximum spindle speed
maximum permissible rotational speed for a work holding or tool spindle specified and set as a machine parameter by the machine manufacturer

3.5.2
maximum work holding device speed
maximum permissible rotational speed of the work holding device specified by its manufacturer

3.5.3
maximum working spindle speed
maximum permissible rotational speed spindle holding the workpiece, depending on clamping conditions, size, mass and balance of the particular workpiece as well as the permissible working speed for the tool(s)

Note 1 to entry: The maximum permissible rotational speed of spindles depends on constructional limits given by the manufacturer(s) of the machine, the spindle or the clamping device, and the size, mass, balance/unbalance of the particular workpiece specified by the machine setter, which varies with the user.

3.5.4
reduced spindle speed in setting mode
maximum permissible rotational speed of the spindle in setting mode

Note 1 to entry: The spindle speed in setting mode is reduced for safety reasons (see 5.2.4.4).

3.5.5
maximum axes speed
maximum permissible speed for axes movement specified and set as a machine parameter by the machine manufacturer

Note 1 to entry: The maximum permissible feed rate of the axes depends on constructional limits specified by the manufacturer of the machine.

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3.5.6
reduced axes speed in setting mode
maximum permissible speed for axes movement in setting mode

Note 1 to entry: The speed for axes movement in setting mode is reduced for safety reasons (see 5.2.4.4).

4 List of significant hazards

4.1 General

The manufacturer of the turning machine shall conduct a risk assessment in accordance with ISO 12100:2010. The list of hazards and hazardous situations in Table 3 is the result of task and hazard identification determined by risk assessment carried out in accordance with ISO 12100:2010, Clause 5, and ISO 12100:2010, 5.4, for turning 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 paying 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) working areas with moving spindle(s), work clamping components, such as chuck and collet, tool carrying slide(s), turret(s), copying unit(s), steady rests, tailstock, indexing spindle carrier, workpiece(s), swarf and chip handling equipment (if integrated);

b) handling devices for workpiece loading/unloading, including bar feeders;

c) external tool magazines and tool changers;

d) chip discharge zone;

e) gear box;

f) rear of the spindle;

g) cam mechanisms;

h) lead screw (Group 1: manual machines without NC functions);

i) feed screw (Group 1: manual machines without NC functions);

j) ball screw (Groups 2, 3 and 4, manual machines with NC capabilities, NC machines and turning centres, automatic turning machines);

k) linear drives.

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4.3 Significant hazards and hazardous situations covered by this International Standard

The significant hazards covered by this International Standard are listed in Table 3. Particular attention is given to hazards arising from the following:

a) the ejection of tools, chucks jaws, clamping devices, workpieces or parts of them, including swarf and chips (see Table 3, B.1);

b) entanglement on or drawing into moving parts of the machine, particularly chucks, powered indexing spindle carrier, powered tools, workpieces (see Table 3, A.4) and workpiece material and bars which are extending at the rear of the spindle;

c) contact with moving parts of the machine, including cutting and crushing between moving and fixed/moving parts of the machine;

d) slip, trip and fall;

e) fire and explosion.

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Table 3 — Overview of hazards and reference to type-B standards

No.[a]	Hazards, hazardous situations and hazardous events	Situations on turning machines	ISO 12100:2010	Relevant type-B standard[b]	Relevant (sub)clause in this International Standard
B.1	**1 Mechanical hazards**				
—	Acceleration, deceleration (kinetic energy)		6.2.2.1 6.2.2.2 6.2.3 a) 6.2.3 b) 6.2.6 6.2.10 6.3.1 6.3.2 6.3.3 6.3.5.2 6.3.5.4 6.3.5.5 6.3.5.6 6.4.1 6.4.3 6.4.4 6.4.5	ISO 6385 ISO 13851 ISO 13854 ISO 13855 ISO 13856-2 ISO 13856-3 ISO 13857 ISO 14118 ISO 14119 ISO 14120 ISO 14122-1 ISO 14122-2 ISO 14122-3 ISO 14122-4 ISO 16156 IEC 60204–1	5.2.1.1 g) 5.2.3 a) 4) ii)
—	Angular parts				5.1.2, 5.2
—	Approach of a moving element to a fixed part				5.1.2 5.2
—	Cutting parts, sharp edges: crushing and shearing				5.1.2 5.2
—	Elastic elements High pressure: fluid injection or ejection Vacuum, Gravity (stored energy) High pressure Height from the ground	Dissipation of accumulated energy inside the machine			5.2.4.5 b) 1) iii) 5.2.2.4 a) 1) 5.2.2.4 c) 6) 5.2.4.4 b) 5.2.4.3 a) 3) 5.2.4.4.1 c) 5.2.4.5 a) 3) 5.8 e) 1) iv) 5.8 h) 4) 5.10 d)
—	Falling objects	Falling workpiece			5.2.3
—	Moving elements: entanglement				5.1.2 5.2
—	Rotating elements: entanglement				5.1.2 5.2
—	Rough, slippery surface: slipping, tripping and falling of persons (related to machinery)	Ejection or spillage of metal cutting fluid (metal removal fluid), lubricants or hydraulic fluid; fall of persons during access to/or at/ from the work position on large machines during setting and machining mode			5.15
—	Sharp edges				5.1.2, 5.2
—	Stability	Loss of stability			5.14
B.3	Assembly and installation Error of fitting	During tool workpiece clamping change	5.5.2.2, 6.4.1.3 6.4.5.1		5.12 6.2.1 to 6.2.3 6.2.9
—	Operation	Restarting the machine after stopping/interruption	5.5.2.2 6.2.11.4 6.2.11.5	ISO 4413 ISO 4414 ISO 14118 IEC 60204–1	5.10
—	Fault finding and troubleshooting	Isolation and energy dissipation	6.2.10	ISO 4413 ISO 4414 ISO 14118 IEC 60204–1	5.8 h)

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Table 3 *(continued)*

No.[a]	Hazards, hazardous situations and hazardous events	Situations on turning machines	ISO 12100:2010	Relevant type-B standard[b]	Relevant (sub)clause in this International Standard
B.4	Falling or ejection of objects	At work clamping, during machining, at bar feed and coolant (workpiece, part of tool, swarf)	6.2.3, 6.2.5 6.2.10 to 6.2.12 6.3.2.1, 6.3.2.2, 6.3.2.7 6.3.3, 6.3.5.2, 6.3.5.4, 6.3.5.5, 6.4.4, 6.4.5	ISO 4413 ISO 4414 ISO 14120	5.13 Annex A Annex B Annex C
B.4	Failure of control system	— dropping or ejection of moving parts of the machine or of a work-piece clamped by the machine — failure to stop moving parts — uncontrolled move-ments (including speed change) — unintended/ unexpected start-up — other haz-ardous events due to failure(s) or poor design of the control system — variation of speed of tools (during setting)	5.5.2.2 6.2.2 6.2.3 6.2.5 6.2.11 to 6.2.13 6.3.5.2 to 6.3.5.4 6.4.3 to 6.4.5	ISO 4413 ISO 4414 ISO 13849-1 ISO 13849-2 ISO 14118 IEC 60204–1 EN 954–1:1996	5.8 5.9 5.10 5.11
B.1	**2 Electrical hazards**				
—	Live parts (direct contact)	At electrical equipment during maintenance			5.3 a)
—	Parts which have become live under fault conditions (indirect contact)	At electrical equipment during setting, machin-ing and maintenance	6.2.9 6.3.2 6.3.3.2 6.3.5.4 6.4.4 6.4.5	IEC 60204–1	5.3 b)
—	Short circuit	At any mode of opera-tion, in case of pene-tration of conducting substances			5.3 c)

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Table 3 — (*continued*)

No.[a]	Hazards, hazardous situations and hazardous events	Situations on turning machines	ISO 12100:2010	Relevant type-B standard[b]	Relevant (sub)clause in this International Standard
B.1	**3 Thermal hazards**				
—	Explosion or flame	Working with flammable metal working fluid or pyrophoric material		EN 13487	5.6 c) 6.2.1 c), n), o) 6.2.8 Annex E
—	Objects or materials with a high or low temperature	At hot tools, chips and workpiece		ISO 13732-1	6.2.2 c)
B.1	**4 Noise hazards**				
—	Manufacturing process (stamping, cutting, etc.) and/or — moving parts, — scraping surfaces, — unbalanced rotating parts, — whistling pneumatics, — exhausting system	At any mode of operation or in maintenance situation	6.2.2.2 c) 1) 6.2.3. c) 6.2.4 c) 6.2.8 c) 6.3.2.1 b) 6.3.3.2.1 6.3.4.2 6.4.3 6.4.5.1 c) 4)	ISO 230-5 ISO 8525 ISO/TR 11688-1	5.4 6.2.6 6.2.8
B.1	**6 Radiation hazards**				
—	Low-frequency electromagnetic radiation Radio frequency electromagnetic radiation	At electrical equipment during setting mode or maintenance	6.2.2.2 c) 4) 6.2.3 c) 6.3.3.2.1 6.3.4.5 6.4.5.1 b) 4) 6.4.5.1 c) 4)		5.5 a) 5.8 k)
—	Optical radiation (infrared, visible and ultraviolet), including laser	At laser equipment during setting mode or maintenance		IEC 60825–1	5.5 b) 6.2.1 g)
B.1	**7 Material/substance hazards**				
—	Biological and microbiological (viral or bacterial) agent	Contact with metal cutting fluids during loading/unloading maintenance, setting mode	6.2.2.2 c) 3) 6.2.3 b) 6.2.3 c) 6.2.4 a) 6.2.4 b) 6.3.1 6.3.3.2.1 6.3.4.4 6.4.5.1 c) 6.4.5.1 g)	ISO 14159	5.6 b) 5.6 d) 6.2
—	Explosive, flammable, combustible	At work zone during machining		EN 13478	5.6 c) 6.2
—	Fume, mist, dust	At delivery system of metal cutting fluid, during setting, machining, maintenance After extinguishing system has been activated			6.2.1 m), Annex F
B.1	**8 Ergonomic hazards**				
—	Design or location of indicators and visual displays units	At operator's position			5.7 a) 5.7 b) 5.7 g)
—	Design, location or identification of control devices	At operator's position		ISO 15534-1 ISO 15534-2 ISO 9355-1 ISO 9355-2 ISO 9355-3	5.7 a) 5.7 b) 5.7 d) 5.7 f)

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Table 3 *(continued)*

No.[a]	Hazards, hazardous situations and hazardous events	Situations on turning machines	ISO 12100:2010	Relevant type-B standard[b]	Relevant (sub)clause in this International Standard
—	Posture, effort	At control devices and during handling of workpiece tools and machine parts	6.2.2.1 6.2.7 6.2.8 6.2.11.8 6.3.2.1 6.3.3.2.1	ISO 9355-1 ISO 9355-2 ISO 9355-3 ISO 11228	5.7 c)
—	Repetitive activity	Inadequate consideration of hand-arm or foot-leg anatomy at workpiece or tool exchange		ISO 6385 ISO 9355-1 ISO 9355-2 ISO 9355-3 ISO 11228	5.7 d)
—	Visibility, local lighting	At cutting process, during setting, handling/positioning of workpiece		EN 1837	5.7 e)
B.1	**9 Hazards associated with environment in which the machine is used**				
—	Electromagnetic disturbances	At NC control equipment during all modes of operation and maintenance	5.5.2.2 6.2.12.2 6.4.5.1 b)		5.8 k)
B.4	Human error, human behaviour	Workstation and/or work process design Inadequate consideration of hand-arm or foot-leg anatomy	6.2.2.1 6.2.7 6.2.8, 6.2.11.8 6.2.11.10 6.3.5.5 6.4.3 to 6.4.5	ISO 9355-1 ISO 9355-2 ISO 9355-3	5.7 g) 5.7 f) 6.1 c) 6.2.4
a	The numbers in this column refer to table numbers in ISO 12100:2010, Annex B.				
b	Reference standards in this column are dated references. See Clause 2 for the relevant publication dates.				

5 Safety requirements and/or protective measures

5.1 General requirements

5.1.1 Overview

Turning machines and turning centres shall comply with the safety requirements and/or measures of this clause. For further hazards which are not dealt with in this International Standard, the machine shall be designed in accordance with the principles of ISO 12100:2010, Clause 5.

For guidance in connection with risk reduction by design, see ISO 12100:2010, Clause 6, and 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 and is given in ISO 13849-1:2006 or in EN 954-1:1996. Therefore, reliability requirements for safety functions are defined as performance level (PL), in accordance with ISO 13849-1:2006, or as category, in accordance with EN 954-1:1996 [see 5.11 b)].

Each machine shall be designed and safeguarded in accordance with the specific requirements and/or protective measures listed in this clause. For some of the requirements, this International Standard offers the choice between two performance levels or two categories [see 5.11 b)]. In cases not specified

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in 5.11 b), performance levels in accordance with ISO 13849-1 or categories in accordance with EN 954-1:1996 shall be determined based on an appropriate risk assessment.

All requirements and/or protective measures given in this clause apply to all groups of turning machines, unless specifically referenced.

5.1.2 Required characteristics for guards for all machine groups

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.

5.1.2.2 Position and safety

The requirements are the following.

a) In terms of 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 and a distance from the hazard zone in accordance with ISO 13857:2008, Table 2. Any opening between the bottom of the guard and the floor shall be in accordance with ISO 13857:2008, Table 7 (≤180 mm).

b) For the guarding of drives, access to mechanical power transmission drives (e.g. chains and sprockets, gears, leadscrews, feedscrews and ballscrews) shall be prevented by fixed guards (including telescope-type guards), unless they are safe by position. If access to these parts is required during normal operation of the machine, interlocked movable guards shall be provided.

   For requirements concerning safety function interlocking devices associated with movable guards, see 5.11 b) 1).

c) For the 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 14119:2013, Clause 6;

   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 interlocking device associated with movable guard, see 5.11 b) 1).

5.2 Specific requirements resulting from mechanical hazards identified in Clause 4

5.2.1 Group 1 machines

5.2.1.1 Primary safeguards for Group 1 machines, manual turning machines without NC

The primary safeguards include the following.

a) A chuck guard, provided to prevent or restrict access to the rotating workpiece clamping device and minimize the effect of chuck jaw ejection. For design and construction, see 5.13. This moveable guard shall be interlocked [see 5.11 b) 1)] to the spindle drive:

   1) the width of the guard shall cover the entire length of the body of the chuck. The guard shall be able to reach to the outmost parts of the normal chuck jaws. The part of the workpiece which protrudes from the chuck shall not be covered;

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2) as a minimum, the guard shall reach near the centreline of the rotating workpiece clamping device.

b) A rear chip guard, provided at the rear of the machine to contain coolant and chips and direct them towards the collection area. The guard shall either be fixed to the machine and extend over the length of the machining area, or for large turning machines, be fixed to the saddle and be at least the width of the saddle. As an alternative to rear fixed guarding, perimeter fencing can be specified.

c) A front chip guard, provided to prevent direct ejection of coolant and chips (swarf) towards the operator's position and direct access to the work zone from this position. The width of the chip guard shall be at least the width of the saddle. Where the chip guard does not extend from the work holding spindle nose to the front of the tailstock when the tailstock is located at the end of the bed, it shall be adjustable in position along the Z-axis (in accordance with ISO 841) and may be attached to the saddle.

d) When a rear spindle guard also provides access to the gear box, it shall be lockable and interlocked to the spindle rotation.

e) Leadscrews and feedshafts shall either be guarded or be safe by position.

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

g) Constant surface speed shall not operate unless a maximum working spindle speed has been entered and registered in the machine. Monitoring of the maximum working spindle speed is required [see 5.11 b) 5)]. The manufacturer of the machine shall indicate in the instructions for use the safe ways to set the maximum working spindle speed. These may include reduced acceleration rates, teach systems or automatic sensing of unbalance. The setting of the maximum working spindle speed shall be cancelled when the machine is powered off.

h) For axis interpolation, engaging a feed movement shall only allow a single path along a principle axis and shall allow no automatic return.

i) Rapid traverse rates shall be limited to

— 6 m/min for small turning machines, and

— 10 m/min for large turning machines.

j) Means shall be provided to prevent the tailstock being unintentionally pulled off the end of the bed.

k) Regarding handwheels, the 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.

l) Protective clothing and training are important. As the operator is not protected from the work zone, special attention shall be given to ensure that the end-user is aware of the training required and the personal protective clothing and other safety items required, e.g. safety glasses, fitted clothing, and so on See instructions in 6.2.

NOTE See Figure 3.

5.2.2 Groups 2, 3 and 4 machines

5.2.2.1 Access to the work zone

Guards shall be provided to mitigate the risks listed in Table 3 (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 5.2, 5.3 and in ISO 12100:2010, Figure 4. For the features of guards used to minimize the hazard of ejection, see 5.13.

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5.2.2.2 Characteristics for guards, specific requirements for Groups 2, 3 and 4 machines

The characteristics of guards and specific requirements for Groups 2, 3 and 4 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. The opening of a guard or actuation of a protective device in Mode 1 shall cause hazardous movements to stop and further movement to be inhibited (see ISO 14118:2000). If the movable guards provide access to the work zone, they shall be additionally equipped with guard locking. Measures to minimize the possible defeat of interlocking device(s) shall be taken (see ISO 14119:2013, 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.

b) For power-operated guards:

   1) the requirements of 5.2.2.2 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 ISO 14120:2002, 5.2.5.2, and shall be equipped with a protective device to avoid shearing hazards at the front edge [see 5.11 b) 9)]. 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 13856-2:2013;

   3) the force to prevent the guard 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;

   4) 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;

   5) these requirements shall only apply to guards as defined in ISO 12100:2010, 3.27.

5.2.2.3 Primary safeguards for Group 2 machines, manually controlled turning machines with limited numerically controlled capability

The primary safeguards for Group 2 machines, manually controlled turning machines with limited numerically controlled capability, are the following.

a) For Mode 0 (manual mode), the requirements in 5.2.1.1 for primary safeguards of Group 1 machines shall also apply. The front chip guard may be carried out by the partial enclosure [see 5.2.1.1 c)].

b) For Mode 1 (automatic mode), a primary safeguard, which meets the requirement of a chuck guard, a front guard or a partial enclosure shall be provided. The front guard shall be interlocked to the spindle whether it is attached to the saddle or not.

c) For small Group 2 machines only, the partial enclosure shall extend from the work holding spindle nose up to the front of the tailstock, when the tailstock is located at the end of the bed.

d) For large Group 2 machines under Mode 1 (automatic mode) only, the requirements in 5.2.2.4 b), c), d) and e), for large Group 3 machines, shall also apply.

NOTE See Figure 4.

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5.2.2.4 Primary safeguards for Group 3 machines, NC turning machines and turning centres

The primary safeguards for Group 3 machines, NC turning machines and turning centres are the following.

a) The specific requirements for small Group 3 machines are the following:

   1) guards shall be designed to contain and/or prevent exposure to swarf/chips, fluids and parts that can be discharged or ejected [see 5.13 and 5.15 b)];

   2) for Mode 0 (manual mode), the requirements for primary safeguards of Group 1 machines shall apply (see 5.2.1.1);

   3) for Mode 1 (automatic mode), the work zone shall be enclosed by fixed and/or interlocked movable guards during machining operations. The guarding arrangements shall be designed to prevent access to the hazard zone.

   NOTE 1 The guard provided to prevent access to the work zone can also serve as an enclosing guard to minimize the risks of ejection described in 5.13.

   NOTE 2 See Figure 5.

b) Among the specific requirements for large Group 3 machines, fixed and movable interlocked guards shall be provided to prevent access to the following hazardous areas from the operator's position (see ISO 14120:2002, 5.2.2 and ISO 13857:2008, Table 2):

   1) if applicable for large Group 3 machines, the requirements for primary safeguards for small Group 3 machines shall apply [see 5.2.2.4 a)];

   2) in other cases, large Group 3 machines may be equipped with

      — movable guards which interlock [see 5.11 b) 1) i)] to the saddle to prevent access to the work zone from the operating position,

      — a platform [see 5.2.2.4 c)],

      — a perimeter fence [see 5.2.2.4 e)] to prevent access to the machining area,

      — guards described in 5.13.2 or 5.13.3.

c) The requirements for the platform on large Group 3 machines are that where close observation of the machining process is required within the area surrounded by the perimeter fence or through the saddle/slide guard, means of safeguarding the operator's work position shall be provided by an enclosure or a platform fulfilling the following requirements:

   1) be adjustable to ensure a safe position for the operator, if necessary;

   2) be designed to ergonomic principles in accordance with ISO 6385;

   3) be equipped with lighting and ventilation for the operating position;

   4) be equipped with means of access and egress to any operating position (e.g. ladder), in accordance with ISO 14122-3 and ISO 14122-4;

   5) be designed so that access to the hazard zone is prevented, e.g. provision of guards with vision panels or adequate safety distances in accordance with ISO 13857;

   6) provide protection for the operator from chip and/or metalworking fluids, and parts that can be discharged or ejected [see 5.13 and 5.15 b)]. Guards provided for this purpose shall extend in height at least 1,80 m from the floor of the platform;

   7) means shall be provided to minimize the risk of crushing, shearing and impact from movable adjustable (horizontally or vertically) operating platforms/enclosures (e.g. bumpers,

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metal roller shutters, pressure-sensitive protective devices). Adjusting the position of the platform/enclosure position shall only be possible in Mode 2 (setting mode) e.g. by hold-to-run control [see 5.11 b) 2)].

NOTE 3 See Figures 6 and 7.

d) In terms of access to the machining area for large horizontal Group 3 machines:

1) any shearing point, e.g. between platform and machine frame, shall either be avoided, e.g. by adjustable end stops, or prevented, e.g. by bumpers where the platform speed exceeds 25 m/min;

2) bumpers shall be in accordance with ISO 13856-3 and shall stop the movement before an impact force of 400 N is reached. The impact force shall be measured using a fixed probe of circular section 80 mm diameter, positioned square to the direction of motion. The active part of the bumper shall be made of flexible material, e.g. rubber, and its width shall be greater than 80 mm;

3) the bumper shall extend on the whole height of the component up to 1 800 mm and the effort exerted by the bumper shall not exceed 400 N.

NOTE 4 See Figure 6.

e) Access to the machining area for large vertical Group 3 machines shall be prevented by a perimeter fence consisting of fixed and interlocked movable guards with guard locking. If floor-mounted, the perimeter fence shall be securely fixed, have a minimum height of 1,4 m and be situated at a distance from the hazard zone in accordance with ISO 13857:2008, Table 2.

NOTE 5 See Figure 7.

5.2.2.5 Primary safeguards for Group 4 machines, automatic turning machines

The requirements of 5.2.2.4 a) 1) and 5.2.2.4 a) 3) shall also apply.

5.2.3 Workpiece clamping conditions

a) The general conditions are the following:

1) workpiece clamping devices shall be in accordance with ISO 16156;

2) workpiece clamping devices, except collets, shall be clearly marked with their maximum work holding device speed (see 6.2.8);

3) it shall not be possible to manually initiate an opening or closing of the workpiece clamping device when the spindle(s) is (are) rotating;

4) for machines equipped with clamping devices other than collets and where programmable spindle speed is available, a program shall not run in machining mode of operation unless the following conditions are fulfilled:

i) machines shall have facilities for entering and/or validating the maximum working spindle speed (see 3.5.3) taking into account the maximum work holding device speed (see 3.5.2) and the workpiece (see 6.2.8) in Mode 2 (setting mode). Failure to enter and/or validate this/these speed(s) at each program change shall prevent the machine running in Mode 1 (automatic mode). The lower speed shall be monitored [see 5.11 b) 5)] and shall not be exceeded;

ii) for large Group 3 machines only, means shall be provided to prevent acceleration and/or deceleration rates that may result in loss of workpiece clamping, e.g. by providing dynamic

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acceleration/deceleration or manual adjustment (soft start/stop usually on manual machines).

5) Chucks, face plates and other work holding equipment shall be mounted to the spindle in accordance with ISO 702-1, ISO 702-2, ISO 702-3 and ISO 702-4.

b) For a power-operated workpiece clamping device:

1) an actuating force sufficient for the safe clamping of the workpiece shall be maintained until the spindle has come to rest (in accordance with ISO 16156:2004, 5.2.1), e.g. by non-return valves on the hydraulic system or a self-locking workpiece clamping device;

2) means shall be provided to monitor the workpiece clamping device actuating force (e.g. by monitoring hydraulic or vacuum pressure) of power-operated workpiece clamping devices. In addition, the jaw stroke(s) of chucks shall be monitored to ensure that there is a sufficient stroke available once the component is clamped. If the required actuating force is not reached or the necessary remaining stroke is insufficient, starting the work holding spindle drive shall be prevented [see 5.11 b) 7)]. If the monitoring of jaw stroke is not possible, other safety measures shall be provided;

3) if the spindle drive is rotating and if the chuck actuating force or the remaining stroke at the workpiece loading position fall below a pre-set value, a machine stop category 1 in accordance with IEC 60204-1 shall be initiated;

4) for Groups 3 and 4 machines only, for machine warm up, filling the machine or finishing production, it shall be possible to run the machine without workpiece(s) in the work holding spindle(s) in automatic mode of operation with guards closed. In that case, the monitoring of the workpiece clamping may be disabled. The manufacturer shall provide a safe procedure to allow the sensing of clamping to be disabled [see 5.11 b) 7)], e.g. by special NC-routines for above-mentioned purposes, by special keys or by access controls.

In machines with counterspindles that transfer the workpiece to another spindle while both spindles are rotating with the same speed, it shall be possible to run a spindle without workpiece in the work holding spindle in automatic mode of operation with guards closed. In this case, the monitoring of the workpiece clamping in either the main spindle or the counterspindle shall be disabled. Means shall be provided to ensure that at least one of the spindles is running with an activated monitoring of the workpiece clamping [see 5.11 b) 7)];

5) For manual loading/unloading, means shall be provided to prevent fingers being trapped. These means may include

i) adjustable jaw stroke not exceeding 4 mm or a guard fulfilling the safety distances in accordance with ISO 13857,

ii) adjustable incremental movements not exceeding 4 mm,

iii) closing speed not exceeding 4 mm/s, or

iv) controls for the workpiece clamping device controlled with hands outside the work zone, e.g. by two-hand control together with a retractable workpiece support.

c) For a manually operated chuck, means shall be provided to prevent the spindle from starting with the chuck key left in the chuck.

NOTE This can be achieved by an interlocked chuck guard or by providing a self-ejecting key (e.g. spring-loaded).

5.2.4 Modes of machine operation

5.2.4.1 Mode selection and/or options

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a) The modes of operation that are mandatory or optional for the specific turning machine are given in Table 1.

b) To select a mode and/or options:

   1) the selection of a mode of 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 5.11 b) 10).

5.2.4.2 Mode 0: manual mode

When Mode 0 (manual mode) is selected, the following requirements apply:

a) the spindle shall only be initiated manually by a control device provided for that purpose when the chuck guard is closed;

b) the turret indexing shall either be manual or powered. Indexing shall only be possible by incremental steps and be initiated when both hands of the operator are outside the danger zone [e.g. by hold-to-run control together with an enabling device, see 5.11 b) 2) and 4)] or when the guard doors are closed (e.g. on Group 2 and 3 machines);

c) axes speed shall be manually selected and rapid traverse movement shall only be possible by hold-to-run control [see 5.11 b) 2)]. Axes speed shall be limited to

   1) 6 m/min, for small turning machines, and

   2) 10 m/min for large turning machines;

d) axes initiation shall only allow one principal axis movement at a time.

5.2.4.3 Mode 1: automatic mode

a) When Mode 1 (automatic mode) is selected and the movable guards are open, no movement of machine elements shall be possible, except the following:

   1) the opening and closing movement of the workpiece clamping device(s) and movement of the tailstock quill for the purpose of changing the workpiece (see 5.2.3);

   2) spindle(s) rotation shall be controlled by hold-to-run control [see 5.11 b) 2)] and shall not exceed 50 r/min and the peripheral speed shall not exceed 1,3 m/s for the largest standard work holding device described in the instruction for use. The speed limit shall be monitored [see 5.11 b) 5)];

   3) cutting fluid/coolant flow shall be automatically shut off when the movable guard for access to the work zone is open.

b) When Mode 1 (automatic mode) is selected and the movable guards are closed, all programmed movements of machine elements are possible. The monitoring of the maximum permissible spindle speed shall be active [see 5.2.3 a) 4) i)].

c) For Group 2 machines (manually controlled turning machines with limited numerically controlled capability) only, when Mode 1 (automatic mode) for Group 2 machines is selected and all safeguards are active (e.g. chuck guard and front guard closed, and speed monitoring active):

   1) all limited numerically controlled capabilities (see 3.4.1.4) can be provided;

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2) rapid traverse movement shall be limited to 10 m/min for linear axes.

5.2.4.4 Mode 2: setting mode, general

As the setting mode is very machine-group-specific, the additional requirements for Groups 2 and 3 machines are given in 5.2.4.4.1, and for Group 4 machines in 5.2.4.4.2.

When Mode 2 (setting mode) is selected and the movable safeguards are open, the following general requirements apply.

a) For requirements to enter/validate the maximum working spindle speed, see 5.2.3 a) 4) i).

b) Automatic tool and workpiece changing mechanisms shall remain disabled. Initiation of their automatic movement shall only be possible after closing the guards.

c) Means shall be provided to prevent hazardous movement of vertical or slant axes under gravity (e.g. redundant brake system). For requirements concerning the safety control function for the prevention of unintended descent of vertical or slant axes, see 5.11 b) 12).

d) When access is given to a hazard zone(s) from more than one position through movable guard(s) and part of a 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 loading/unloading:

   1) for safety requirements and/or measures concerning handling devices for workpiece loading/unloading, see 5.2.5.2;

   2) the handling device setting shall only be possible by hold-to run control at a reduced speed not exceeding 2 m/min [see 5.11 b) 6)] or with the guards closed;

   3) where access is required with the guards open or the protective device(s) suspended, powered motion shall only be initiated under the 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 control device shall be at a safe distance from the hazardous situation, so as to keep both hands outside the hazardous zone. The distance to the hazard shall meet the requirements of ISO 13855. For requirements concerning the safety function's enabling device and hold-to-run control, see 5.11 b) 2) and 4). No hazardous movement shall arise from the actuation of any sensor or feedback device;

   4) if a robot is used for workpiece loading/unloading, the requirements of ISO 10218-2 shall apply.

5.2.4.4.1 For Mode 2: setting mode for Group 2 and Group 3 machines (manually controlled turning machines with limited numerically controlled capability and numerically controlled turning machines and turning centres). When the setting mode of operation is selected and the movable guards are open, movement of machine elements shall only be possible under the following conditions.

a) Axes feed movements shall be limited to a feed rate not exceeding 2 m/min and the feed rate limit shall be monitored [see 5.11 b) 6)]. The axes feed movement shall be

   1) controlled by a hold-to-run control [see 5.11 b) 2)], or

   2) limited to incremental movement of not more than 6 mm.

b) Indexing (rotation) of powered turrets shall only be possible by incremental steps and be initiated when both hands of the operator are outside the danger zone [e.g. by two-hand control (see ISO 13851)] or by hold-to-run control together with an enabling device [see 5.11 b) 4)] or when the guard doors are closed. If the turret is controlled as an NC axis, the requirements of 5.2.4.2 b) shall apply for feed rate as well as for maximum surface speed.

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c) Cutting fluid/coolant flow shall be automatically shut off when the movable guard for access to the work zone is open.

d) Power-operated tool spindle(s) shall not exceed 50 min^{-1}.

e) For small Groups 2 and 3 machines only, the rotational speed of the workpiece holding spindle shall not exceed 50 min^{-1}. The rotation shall be controlled by hold-to-run control or enabling device and the speed limit shall be monitored [see 5.11 b) 2) or 4) and 5)].

f) For large Groups 2 and 3 machines only, the rotation of the workpiece holding spindle and faceplate movements shall be limited by the peripheral speed of the work holding device and shall not exceed 1,3 m/s. The particular work holding spindle speed shall be monitored [see 5.11 b) 5)] and be controlled from outside the hazard zone using a hold-to-run control or an enabling device [see 5.11 b) 2) or 4)].

5.2.4.4.2 For Mode 2: setting mode for Group 4 machines (single- or multi-spindle automatic turning machines). When the setting mode of operation is selected and the movable guards are open, movement of machine elements shall only be possible under the following conditions.

a) Axes feed movements shall only be possible where:

   1) axes feed rate does not exceed 2 m/min and the feed rate limit is monitored [see 5.11 b) 6)],

   2) axes feed movements are controlled for each axis by a hold-to-run control [see 5.11 b) 2)], or

   3) axes feed movements are limited to incremental movements of not more than 6 mm;

b) For the rotation of powered tools and/or work holding spindle(s)

   1) rotation shall be monitored and not exceed 50 min^{-1} [see 5.11 b) 5)],

   2) movement shall be controlled by a hold-to-run control [see 5.11 b) 2)], and

   3) on mechanically controlled machines where no reduced speed function is provided, operation of powered tools or work holding spindles shall only be possible under a two-hand control device of type II or IIIB in accordance with ISO 13851:2002, 6.3. The location of the two-hand control device shall be in accordance with ISO 13855;

c) Movement of the spindle carrier shall only be possible:

   1) by rotation at a limited peripheral speed not exceeding 2 m/min and the speed limit shall be monitored [see 5.11 b) 5)]. Movement shall be controlled by a hold-to-run control [see 5.11 b) 2)];

   2) by indexing from one position to another when both hands of the operator are outside the hazard zone, e.g. by using a hold-to-run control device together with an enabling device [see 5.11 b) 2) and 4)] or by a two-hand control device of type II or type IIIB in accordance with ISO 13851:2002, 6.3. The location of the control device shall be in accordance with ISO 13855.

d) For cam mechanism zones, the powered movements shall only be possible by using a hold-to-run control device together with an enabling device [see 5.11 b) 2) and 4)], or by using a two-hand control device located close to the cam mechanism access door.

5.2.4.5 Service mode

Service mode shall only be provided for service staff, who are trained and authorized by the machine manufacturer.

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For the instructions for use, see 6.2.8.

a) Generally, in service mode:

   1) for the selection of service mode 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. from an outside 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 operation shall be selectable. The instructions for use shall require removing the device after completing service activities;

   2) automatic workpiece changing mechanisms shall remain disabled. Initiation of their automatic movement shall only be possible by reselection of Mode 1;

   3) means shall be provided to prevent 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 vertical or slant axes, see 5.11 b) 12);

   4) according to the hazard analysis, additional safety measures may be necessary, such as secondary guards, barriers or screens in combination with warning signs, if possible;

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

   1) machining shall not be possible in service mode:

      i) reduced axes speed [see 5.2.4.4.1 a)] for all axes shall be used and monitored [see 5.11 b) 6)]. This shall not exceed 2 m/min;

      ii) continued moving cycles shall be possible (e.g. repeatability test);

      iii) if the hazard analysis indicates that the pressure of coolant injection can create hazards, the coolant ejection shall be disabled;

      iv) if the movement of the tool changer is foreseen, the requirements of 5.2.5.5 b) shall apply;

      v) simultaneous rotation of the spindle and axis motion shall be limited to the reduced speeds for Mode 2 (setting mode) and shall be monitored [see 5.11 b) 5) and see 5.11 b) 6)];

   2) each peripheral device (tool changer, swarf conveyor, etc.) can only be enabled individually. It may be necessary to rotate the tool holder to ensure the safe and reliable working of the tool change mechanism, in which case the rotation speed shall be limited to a maximum surface speed of 2 m/min or initiated from control devices located outside the reach of hazardous movements in accordance with ISO 13857 [see 5.11 b) 6)];

   3) if the working spindle speed exceeds 50 r/min or the peripheral speed exceeds 1,3 m/s and no chuck guard is provided [see 5.2.1.1 a)], the front door of the machine shall be equipped with an additional position switch. The position switch shall be interlocked with the spindle drive and shall permit spindle operation only when at least the guard covers the entire length of the body of the chuck;

   4) warning signs shall be displayed adjacent to the mode switch showing a description and diagrams of the safety measures that have to be enforced when this mode is enabled.

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5.2.5 Optional or additional equipment for turning machines

5.2.5.1 Special requirements for machines equipped with bar feed

If the machine is equipped with bar feed devices, the following requirements shall be fulfilled:

a) access to rotating or moving bars or moving parts of the bar feed shall be prevented by fixed and/or interlocked movable guards [see 5.2.2.2 a)]. Access shall only be possible when the hazardous movements have ceased in accordance with ISO 14119;

b) indexing the bar feed device shall not be possible when the guards are open;

c) for requirements concerning the safety function interlocking devices associated with movable guards applied to bar feed devices, see 5.11 b) 1) viii);

d) the guards for access to the machine's work zone shall be interlocked with the bar feed system to prevent the feeding of the bar in the machining mode of operation when the guard(s) is/are open;

e) barfeeding into the work zone shall only be possible in Mode 2 (setting mode) with the work zone guard opened under hold-to-run control [see 5.11 b) 2)] at a speed not exceeding 2 m/min or by two-hand control from outside the work zone;

f) means shall be provided to stop the barfeeding when the remaining bar length is no longer sufficient to ensure that a safe grip can be achieved (see 6.1 for marking).

5.2.5.2 Handling devices for manual or automatic workpiece loading/unloading

a) If the machine is equipped with handling devices for workpiece loading/unloading, the following general requirements shall be fulfilled (specified in ISO 10218-2:2011 and ISO 11161:2007 + Amd1:2010):

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

   2) access to the hazardous movements of handling devices shall be prevented by means of fixed and/or interlocked movable guards [see 5.11 b) 1) iii)] or hazardous movement(s) shall be either stopped or inhibited by the actuation of protective devices (e.g. interlocked guard or light curtain);

   3) for requirements concerning the setting mode of handling devices for workpiece loading/unloading, see 5.2.4.4 b);

   4) actuation of a machine's emergency stop device shall also initiate the emergency stop function of the handling device;

   5) when access to the handling device hazard zone is possible, access from that area to the machine work zone shall not be possible or, alternatively, the machine shall be in stopped condition and unexpected start-up shall be prevented (see ISO 14118). Access to hazardous movements of the handling device and any other dangerous movement of the machine, e.g. in the machine work zone, shall be prevented by means of fixed and/or movable guards interlocked with guard locking.

b) For Group 4 machines (single- or multi-spindle automatic turning machines) only, means shall be provided to take samples of machined workpieces without allowing access to hazardous movements.

5.2.5.3 Machines equipped with a tailstock and/or quill

a) 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).

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b) For machines with power-operated tailstock and/or quill:

1) the powered movement of the quill shall not exceed 1,2 m/min when the guard is open [see 5.11 b) 6)]; forward movements of the quill shall be controlled either

— with two hands outside the work zone (e.g. by two-hand control),

— hold-to-run control [see 5.11 b) 2)],

— with a 3-position-foot switch and stop on release and retraction on foot pedal full down, or

— with a 2-position-foot switch and stop on release;

2) means shall be provided to monitor the clamping force of the quill [see 5.11 b) 7)], and for the automatic cycle to be brought to a controlled stop if the clamping force falls below a pre-set limit;

3) manual initiation of powered tailstock and powered quill movements shall not be possible when the work holding spindle is rotating [see 5.11 b) 7)];

4) either

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

— the clamping limit shall be monitored by a limit switch which is interlocked with the spindle rotation [see 5.11 b) 7)];

5) powered movement of the tailstock body towards the workpiece when the guard is open shall only be by using a hold-to-run control [see 5.11 b) 2)]. The tailstock body can retract to the defined position by one operation considering the requirements of ISO 13854 for the necessary gaps to avoid crushing. The maximum traverse rate of the tailstock body shall not exceed 2 m/min.

5.2.5.4 Chip collection and removal

a) Access to hazardous parts of the chip collection and removal systems shall be prevented by fixed and/or interlocked movable guards [see 5.2.2.2 a)] unless they are otherwise safe by position in accordance with ISO 13857.

b) When these interlocked movable guards are open, movement of the swarf collection and removal system shall be prevented. Where access to dangerous parts of the swarf collection system (e.g. belt or screws) is possible from the operator's position, movements of these parts shall be prevented when the work zone guards are opened. Where movement of the chip collection and removal system is required with the movable guards opened (e.g. for cleaning), this shall be possible only under hold-to-run control [see 5.11 b) 2)] and an emergency stop device shall be provided in the vicinity.

c) The hazards in the chip discharge area shall be safeguarded by guarding or perimeter fencing preventing access to crushing and entanglement and permanently mounted labels warning of any residual risk, as defined in ISO 12100:2010. Where movable guards are used, they shall be interlocked with the chip conveyor system [see 5.2.2.2 a)].

5.2.5.5 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 interlocked movable guards [see 5.2.2.2 a)] in accordance with ISO 14119:2013, 6.1. For requirements concerning safety functions for interlocking devices associated with tool changer, tool magazine, see 5.11 b) 1) iii).

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b) When the interlocked movable guard(s) for access to the tool magazine is (are) open, the tool magazine drive shall be stopped in an appropriate stop category in accordance with IEC 60204-1:2009, 9.2.2. In Mode 2 (setting mode) or service mode with the interlocked movable guard open, powered 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 for continuous movement. This movement shall be at a maximum surface speed of 2 m/min or initiated from control devices located outside the reach of hazardous movements in accordance with ISO 13857. For requirements concerning safety functions for interlocking devices associated with tool changer, tool magazine, see 5.11 b) 1) iii).

c) Where whole body access into the tool magazine is possible, presence sensing devices shall be provided to prevent any movement of the tool magazine or other accessible hazardous machine movement. It shall be possible to view the movement of the tool magazine with the interlocking guard in the closed position. 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 6.2).

d) Fixed or interlocked movable guards shall prevent access to movable parts of the tool changer. When interlocking 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 60529:2003, Clause 6, for the prevention of electric shock and IEC 60529:2003, Clause 7, for protection against short circuits and for protection against overloading. The degree of protection of all electric components shall be IP54 minimum in accordance with IEC 60529:2003. In particular, the following requirements in the relevant clauses of IEC 60529:2003 shall be fulfilled:

      i) Clause 7 for protection of equipment,

      ii) Clause 8 for equipotential 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 is not considered significant for machines 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 have a degree of protection of IP55.

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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 sources of airborne noise on these machines include

— the metal cutting process,

— the spindle/axes drives,

— the bar feed mechanisms (if provided), and

— the exhaust system (if provided).

Operating conditions for noise measurement shall be in accordance with ISO 8525.

The determination of the noise emission shall be in accordance with ISO 230-5.

The declaration of the noise emission values shall be in accordance with 6.2.6.

5.5 Specific requirements resulting from radiation hazards

a) For low-frequency radiation, radio frequency radiation and microwaves, see 5.8 k). See EN 12198-1, EN 12198-2 and EN 12198-3 for more information.

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

5.6 Specific requirements resulting from material or substance hazards

a) As the materials that may be processed depend on specific applications, it is not possible to provide detailed recommendations for the reduction of the risks in this International Standard. However, for metalworking fluids, the following requirements apply.

b) The requirements for metal removal fluids/coolant are:

   1) machines shall have facilities to enable the taking of samples of removal fluid/coolant, cleaning of the system and changing of filters (see 6.2);

   2) metal removal fluids shall drain away under gravity from the machine towards the tank to avoid stagnant areas remaining on or within the machine.

c) If a fire and/or explosion risk exists:

   1) the machine, including the control system, shall be designed so as to allow for its connection to fire detection equipment, an extinguishing system, an alarm, a pressure relief, etc., according to the manufacturer's recommendation (see examples in Figures E.1 and E.2);

   2) if the coolant supply or the exhaust system is not functioning correctly, a start-up of the machine shall be prevented (see Figure E.2, item 5);

   3) in the case of malfunction of the coolant supply, the process shall be stopped automatically in an appropriate manner, e.g. separation of tool and workpiece and switching off spindle, tool drives and exhaust system;

   4) in the case of fire detection, the exhaust system shall be stopped in an appropriate manner. The time delay until the air flow stops increases the amount of extinguishing agent, if an automatic extinguishing system is used.

   NOTE Risks arising from fire and explosion depend on the actual conditions of use of the machine and/or the use of flammable fluids and are considered individually (see EN 13478:).

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d) The following are the requirements for biological or microbiological (viral or bacterial) hazards:

1) 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;

2) to avoid stagnant areas remaining within the machine, metalworking fluid shall drain under gravity from the machine towards the tank;

3) discharge pipework shall have a sufficient diameter and slope to minimize sludge settlement;

4) the metalworking fluid system shall be provided with filtration;

5) when sediment build-up occurs, the design shall facilitate cleaning (e.g. rounded corners in containers). Cleaning shall not require drainage of the whole system (see ISO 14159);

6) the inside of tanks shall not contribute to the growth of bacteria (e.g. smooth, unpainted surfaces);

7) metalworking fluid containers shall have covers designed to prevent the ingress of foreign matter;

8) 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;

9) where a turning machine is provided with enclosed guards used with metal removal fluid (coolant), that 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 Specific requirements resulting from neglect of ergonomic principles hazards

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

— ISO 12100:2010, Table B.1, No. 8;

— 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, category 2 stopping, 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 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 a collar push button or a double action control device;

2) no mode selection switch or start control that initiates Mode 1 (automatic mode) shall be provided at any point on the machine other than the main control panel. A separate start switch may be provided at a position deviating from the main control panel, if the operator has a better view of the dangerous zone. If more than one start switch is 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 Mode 2 (setting mode) 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;

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4) when multiple controls are provided for machine movements in Mode 2 (setting mode), 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:

1) workpieces, tooling and accessories shall be easy to move. Lifting equipment may be required for parts over 10 kg in mass (see ISO 11228);

2) where work 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, tool pockets or tool holders shall be positioned to prevent excessive reaching into the machine (see ISO 11228);

4) control devices to operate clamping or gripping devices (e.g. drawbars, chucks) shall be positioned to avoid excessive reaching while supporting the mass of the tool or workpiece (e.g. application of foot controls) (see ISO 9355-3);

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 inadequate 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 ISO 6385, ISO 9355-1, ISO 9355-2, ISO 9355-3; ISO 11228; ISO 13855).

e) Work zone lighting shall be provided in all modes. It shall be at least 500 lx at one chuck diameter distance in front of the spindle nose on the spindle axis for horizontal spindle machines and 500 lx on the surface of the work clamping device for vertical spindle machines (see EN 1837).

f) For design location or identification of manual controls, input devices (e.g. keyboards, keypads, push buttons) shall be in accordance with ISO 9355-1 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 ISO 9355-1, ISO 9355-2 and ISO 9241 (all parts)].

5.8 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 5.2.2.2 a).

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

1) control systems shall be designed in accordance with ISO 4413:2010, ISO 4414:2010, IEC 60204-1:2009 and with ISO 13849-1:2006 or EN 954-1:1996. Unexpected machine movements (e.g. spindle rotation, axis movement, tool release from the spindle) shall be prevented (see ISO 14118);

2) where access is provided to programmable functions for alterations in Mode 1 (automatic mode), e.g. for tool geometry offset correction, it shall be lockable to prevent unauthorized access to program data or programmable functions. This may be achieved by the use of a password or a key switch;

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3) safety-related software shall be protected against unauthorized 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 5.11 b) 13);

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 5.2.2.2 b);

4) unexpected start-up of hazardous movements, e.g. of work holding spindle, axes, indexing spindle carrier, tool holding slides or workpiece clamping devices, shall be prevented in accordance with ISO 14118:2000, Clause 6, when the movable guards are open or in Mode 0 (manual mode);

5) in Mode 1 (automatic mode), the machine may only be started or restarted when the guards are closed by actuation of the start device provided for that purpose. See this subclause and IEC 60204-1:2009, 9.2.5.2.

d) The following requirements for spindle and axis speed monitoring apply to all rotational speed limit monitoring and axis feed limit monitoring in all modes of operation, except Group 1 machines (Manually controlled turning machines without numerical control):

1) the maximum permissible spindle speeds and maximum permissible axis feeds depend on the mode of operation and shall be monitored accordingly. This also includes the maximum work holding device speed, the maximum working spindle speed or the reduced spindle speed in setting mode and the differences between small and large machines;

2) if one of the maximum permissible speed or feed limits is exceeded, a category 1 stop, in accordance with IEC 60204-1:2009, 9.2.2, shall be initiated automatically;

3) for requirements concerning safety functions for speed limit monitoring of workpiece and tool spindles as well as speed limit monitoring of axes, see 5.11 b) 5) and 6).

e) The requirements for slide movement are the following:

1) slide movements may be achieved by manual actuation or by power driving through gearing from the work holding spindle or separate drive motor(s)/actuators:

i) direction of slide movement shall be consistent with the direction of the control device (specified in ISO 447);

ii) starting slide movements under Mode 0 (manual mode), each slide movement shall be manually initiated;

iii) unexpected start-up of powered slide movement shall be prevented (see ISO 14118:2000, Clause 6);

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

2) for requirements concerning safety functions for starting of axes movements or unintended descent of vertical or slant axes, see 5.11 b) 12) and 14).

f) The following requirements for a safe category 2 stop do not apply to mechanically controlled Group 4 machines (multi-spindle machines):

1) a category 2 stop function, which is initiated by a stop device, shall be provided for each machine mode of operation. When a category 2 stop function is initiated, the energy supply to axes drive

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motors, work holding device actuators (e.g. power-operated chuck or collet) and NC equipment need not be removed (category 2 stop in accordance with IEC 60204-1:2009, 9.2.2). However, for power to remain connected to the drive motor for the work holding spindle and tool holding slides, it shall be monitored to detect movement (see ISO 14118:2000, 6.4);

2) for requirements concerning the safety function's safe category 2 stop, see 5.11 b) 11);

3) when the machine is stopped by the safe category 2 stop, opening the guard shall keep the machine stopped in category 2 (see IEC 60204-1:2009, 9.2.2);

4) a fault in the safety-related part of the control system for the safe category 2 function shall result in a category 1 stop, if possible, or in a category 0 stop, according with IEC 60204-1:2009, 9.2.2.

g) For restoration of energy supply after an interruption, control system design shall ensure that automatic restart is prevented and re-actuation of the start control is always required to initiate powered 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, 5.4.7.2.1, ISO 4414:2010, 5.2.8, and IEC 60204-1:2009, 5.3. For the dissipation of stored energy, see ISO 14118:2000, 5.3). (See also Clause 5 and 5.3.1.3 of ISO 14118:2000);

3) the device for disconnecting electrical supply shall be in accordance with IEC 60204-1:2009, 5.3, with the exception that the isolator shall not be of type d) or e) of IEC 60204-1:2009, 5.3.2;

4) when the machine has its own hydraulic pump and/or pneumatic compressor, the electrical isolation of the machine shall also cut the supply of 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 14118:2000, 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 4414:2010.

j) Hydraulic systems shall be in accordance with ISO 4413:2010.

k) The requirements for external influences on the electrical equipment are the following:

For electromagnetic compatibility,

1) Immunity: electronic control systems shall be designed and installed so as to be protected from electromagnetic interference and so as to be 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.

5.9 Specific requirements resulting from variation in rotational speed of tool hazards

For requirements concerning the safety function speed limit monitoring of tool spindles, see 5.11 b) 5).

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

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 5.11 b) 12);

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 4413:2010 and ISO 4414:2010);

f) means shall be provided for the isolation of the energy supply (see ISO 4413:2010, 5.3.2.2, ISO 4414:2010, 5.28 and IEC 60204-1:2009, 5.3; for the dissipation of stored energy, see ISO 14118:2000, 5.3).

5.11 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 include 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 13849-1:2006 or EN 954-1:1996.

b) The safety functions shall fulfil the accordant requirements given in this subclause. The manufacturer has the choice between two reference standards for each safety function listed in the following table:

   If ISO 13849-1:2006 is applied, the required performance level (PL_r) shall be fulfilled.

   If EN 954-1:1996 is applied, the required category shall be fulfilled.

NOTE For the determination of the performance level, see also example of calculation in Annex F.

		Required performance level PL_r according to ISO 13849-1:2006	**Required category according to** EN 954–1:1996
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 by the operator;	d category 3	3
	work zone only for maintenance;	c	1
ii)	transmissions, drive mechanisms;	c or d[1)]	1 or 3[1)]
iii)	tool changer, tool magazine;	d	3
iv)	handling device for workpiece loading/unloading;	c or d[1)]	1 or 3[1)]
v)	pallet changer;	c or d[1)]	1 or 3[1)]

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	vi) chip conveyor;	c	2
	vii) access to pits, gates in perimeter fencing;	c or d[1)]	1 or 3[1)]
	viii) bar feed devices;	c	1
	ix) mechanical power transmission drives accessible during normal operation.	c or d[2)]	1 or 3[2)]
2)	Hold-to run control;	d[3)]	3[3)]
3)	Control system with electronic handwheel;	see 6)	see 6)
4)	Enabling device;	d	3
5)	Rotational speed limit monitoring for spindles [see 5.8 d)];	d	3
6)	Linear axes speed limit monitoring (includes electronic handwheel);	c	2
7)	Control system of tool clamping and workpiece clamping;	b	1
8)	Emergency stop [see 5.11 c)];	c	1 or 3[4)]
9)	Prevention of crushing hazard at power-operated guards/doors with edge protection by e.g. pressure-sensitive protective devices (PSPD);	d	2 or 3[5)]
10)	Operation mode selection function;	c	1
11)	Safe category stop 2 in accordance with IEC 61800–5-2:2007;	c	2 or 3[6)]
12)	Control function to prevent unintended descent of vertical or slant axis;	c or d[7)]	2 or 3[7)]
13)	Start and restart function [see 5.8 c)];	c	1
14)	Start axis movement [see 5.8 e)].	c	1

1) Based on S1 and P2, decision F1 or F2 depend on frequency of access. If it is once or more per hour, PL_r= d or category 3 shall be used. If it is less than once per hour, PL_r = c or category 1 may be used.
2) If it is scarcely possible to avoid hazard (P2, see F.2) the interlocking shall conform to PL_r = d or category 3. If it is possible to avoid hazard (P1, see F.2) the interlocking can conform to PL_r = c or category 1.
3) If PL_r = d or category 3 cannot be achieved, a combination of hold-to run and enabling device complying with P_r = d or category 3 shall be used.
4) If the emergency stop function is hardwired, category 1 shall be used. In other cases, category 3 shall be used.
5) Based on the risk assessment and taking into account the mass and the velocity of the door.
6) Category 2 for axes movement and category 3 for spindle rotation.
7) Whenever a hazardous descent of vertical or slant axis occurs, PL_r = c or category 2 can only be selected if a realistic chance of avoiding an accident or significantly reducing its effect is given; PL_r = d or category 3 can be selected if there is almost no chance of avoiding the hazard.

c) Emergency stop:

1) emergency stop functions shall be category 1 (or category 0/determined by the risk assessment) and be in accordance with IEC 60204-1:2009, 9.2.5.4.2, ISO 12100:2010, 6.3.5.2 and ISO 13850:2006;

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2) an emergency stop function shall be initiated by an emergency stop device(s) which shall be in accordance with IEC 60204-1:2009, 10.7 and ISO 13850:2006. An emergency stop control device shall be provided at each operator's position including:

   i) at the main control panel;

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

   iii) close to and inside the enclosure or tool magazine (where whole body access is possible);

   iv) when a tool magazine is present and separate from the machining area;

   v) at the handling device station for workpiece loading and unloading (if present and separate from the main operator's position);

   vi) at the bar loading and unloading station (if present and separate from the main operator's position).

5.12 Specific requirements resulting from errors of fitting hazards

Any part dismountable by the user for setting or maintenance purposes, e.g. cam, turret, tool holder and mechanical device shall have provisions for preventing errors of fitting, e.g. pins, asymmetrical mounting (see 6.2).

5.13 Specific requirements resulting from ejected fluids or objects hazards

5.13.1 General requirements

a) For the containment of processed materials and fluids, guards shall be provided to retain or contain the foreseeable ejection of hydraulic and pneumatic fluids (see ISO 4413 and ISO 4414), processed material and metalworking fluid. Such guards shall be designed in accordance with ISO 14120:2002, Clause 8. These may take the form of a deflecting adjustable guard fixed to the spindle head to direct processed material/metalworking fluid towards their collecting area, or of a fixed guard covering the whole area of ejection.

b) Guards against the ejection risk:

   1) guards shall be provided around the work zone to minimize the hazard of ejected machine components, tools (or parts of them), swarf, chips or coolant (see also 5.1 and 5.2);

   2) guards enclosing the work zone shall be designed and constructed to withstand the maximum foreseeable impact energy. Where direct impact is foreseeable, impact energy is dependent on the diameter of the largest work clamping chuck the machine can be equipped with and its maximum peripheral speed (see Annexes B and C);

   NOTE 1 This does not apply to the front chip guard of Group 1 machines, as this is covered by the chuck guard.

c) Whipping of a bar section of maximum dimension and speed (see Annex C).

d) Materials used for the construction of guards shall meet the resistance class as defined in Annex A for the work clamping device fitted to the machine. They have to protect both sides against cutting fluid chips and coolant. Information on the test equipment is given in Annex B.

e) Where guards are fitted with vision panels which are also intended to minimize the hazard of ejected parts, special consideration shall be given to the selection of materials and method of fixing (see ISO 14120:2002, 5.2.2). Material for vision panels (e.g. polycarbonate) which are prone to a reduction in impact resistance over time (ageing) due to contamination by lubricants, cleaning agents, solvents, metalworking fluids and abrasion shall be provided with additional all-around protection, e.g. sealed multi-layer or laminated construction, to prevent these harmful effects

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during the anticipated service life of the machine. Note that hardcoated polycarbonate does not prevent the ageing effect; it shall have an adequate multilayer or laminate construction.

NOTE 2 This does not apply to the front chip guard of Group 1 machines, as this is covered by the chuck guard.

f) Examples of materials with known resistance class are shown in Annex B.

g) Where direct impact is not foreseeable, guards shall be manufactured with at least 2 mm thick sheet steel with a minimum tensile strength, R_m, of 369 N/mm^2 or 6 mm thick polycarbonate with a minimum tensile strength of 68 N/mm^2 and all around protected against cutting fluids, chips and coolant.

h) Where hazards are generated due to the ejection of a workpiece caused by reasonably foreseeable misuse, the supplier shall provide the user with information which clearly indicates the possibility of ejected workpieces causing catastrophic guard failure. The user shall ensure that protective measures recommended by the supplier are carried out such that the residual risk is acceptable (see 6.2, 6.2.1 and 6.2.3).

i) Regarding tool retention, for power-operated tool drawbars, the drawbar shall be designed to avoid risks from tool ejection if the power fails. The drawbar mechanism shall be monitored so that a failure to achieve correct registration or clamping of the retention knob on the tool shall inhibit the spindle start control in all operating modes. Unclamping of the tool by releasing the drawbar shall be inhibited during spindle rotation [see 5.11 b) 6)].

5.13.2 Guards for large vertical Group 3 machines (NC turning machines and turning centres)

a) Fixed guards and/or interlocked movable guards shall be provided to contain the chips/swarf and/or metalworking fluids and parts of tools or parts of workpieces and to deflect them towards the collection area.

b) The guards shall be designed to prevent accumulation of chips and fluids on the guard structure. In addition, plain fixed and movable interlocked guard with guard locking [see 5.2.2.2 a), if access is necessary] shall be provided around the face plate and inlet of the chip removal system and shall extend to at least 0,250 m above the plate surface.

c) The safeguarding around the work zone shall be made of at least 3 mm thick sheet steel or similar strength material. Vision panels incorporated into the work zone guarding system shall be made of at least 8 mm thick polycarbonate, protected all around against cutting fluids, chips coolant or equivalent (impact energy 3 000 J). This safeguarding may be combined with the safeguarding for access to the machining area from the floor or from the platform (see Figure 7).

5.13.3 Guards for large horizontal Group 3 machines (NC turning machines and turning centres)

a) Guards shall be provided to contain chips/swarf and/or metalworking fluids and parts of tools or parts of workpieces and to deflect them towards the collection area.

b) The guards shall be designed to prevent accumulation of chips and fluids on the guard structure. At the rear of the machine, guards shall be provided to contain chip/swarf and/or metalworking fluids and parts of tools or parts of workpieces. The guards shall be fixed to the saddle or the machine. When fixed to the saddle, the guards shall extend over the total width of the saddle. When fixed to the machine, the guards shall extend over the total width of the machining area.

c) In addition, plain fixed and movable interlocked guard(s), if access is necessary, shall be provided at the operator platform or slide and shall extend over at least 1,8 m from the operator position floor and have the width of the operator platform or slide. Any movable part of this safeguarding shall be interlocked [see 5.2.2.2 a)] with the work holding spindle drive. The displacement of this safeguarding shall be interlocked with guard locking to the saddle displacement. The safeguarding around the work zone shall be made of at least 3 mm thick steel. Vision panels incorporated into

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the work zone guarding system shall be made of least 8 mm thick polycarbonate, protected at both sides against cutting fluids, chip coolant or equivalent (impact energy 3 000 J) (see Figure 6).

5.14 Specific requirements resulting from loss of stability hazards

Machines shall be designed and constructed so that they are stable under foreseeable operating conditions, and without risks of overturning, falling or unexpected movement. When the use of foundation bolting is one of the measures used to help prevent overturning, manufacturers shall specify the bolts and foundation requirements necessary.

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 handholds, footholds, and, where necessary, slip-resistant surfaces. The requirements of ISO 14122-1, ISO 14122-2 and ISO 14122-3 shall be fulfilled. Warnings about hazards and precautions shall be given in the information for use (see Clause 6).

b) To avoid contamination of floors, where a fluid application 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.

5.16 Verification of the safety requirements and/or protective measures

Type tests shall be used to verify the safety requirements and/or protective measures in accordance with Table 4. See also Annex D for examples.

Table 4 — Verification methods

(Sub) clause	Item	Verification method				
		Visual inspection	Functional test	Measurement	Calculation	Documentation
5.1	**General requirements**					
5.1.2	Required characteristics for guards for all machine groups	X	X	X		X
5.2	Specific requirements resulting from mechanical hazards identified in Clause 4					
5.2.1	**Group 1 machines**					
5.2.1.1	Primary safeguards for Group 1 machines, manual turning machines without NC	X	X	X		X
5.2.2	**Groups 2, 3 and 4 machines**					
5.2.2.1	Access to the work zone	X	X			X
5.2.2.2	Characteristics for guards, specific requirements for Groups 2, 3 and 4 machines	X	X			X
5.2.2.3	Primary safeguards for Group 2 machines, manually controlled turning machines with limited numerically controlled capability	X	X			X

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Table 4 *(continued)*

(Sub) clause	Item	Verification method				
		Visual inspection	Functional test	Measurement	Calculation	Documentation
5.2.2.4	Primary safeguards for Group 3 machines, NC turning machines and turning centres	X	X		X	X
5.2.2.5	Primary safeguards for Group 4 machines, automatic turning machines	X	X		X	X
5.2.3	Workpiece clamping conditions	X	X	X		X
5.2.4	**Modes of machine operation**					
5.2.4.1	Mode selection and/or options	X	X			X
5.2.4.2	Mode 0: manual mode	X	X			X
5.2.4.3	Mode 1: automatic mode	X	X			X
5.2.4.4	Mode 2: setting mode, general	X	X			X
5.2.4.5	Service mode	X	X			X
5.2.5	Optional or additional equipment for turning machines	X	X			X
5.2.5.1	Special requirements for machines equipped with bar feed	X	X			X
5.2.5.2	Handling devices for manual or automatic workpiece loading/unloading	X	X			X
5.2.5.3	Machines equipped with a tailstock and/or quill	X	X			X
5.2.5.4	Swarf collection and removal	X	X			X
5.2.5.5	Externally accessible tool magazine, tool transfer and tool changing mechanism	X	X			X
5.3	Specific requirements resulting from electrical hazards	X	X			X
5.4	Specific requirements resulting from noise hazards	X	X			X
5.5	Specific requirements resulting from radiation hazards	X	X			X
5.6	Specific requirements resulting from material or substance hazards	X	X			X
5.7	Specific requirements resulting from neglect of ergonomic principles hazards	X	X			X
5.8	Specific requirements resulting from unexpected start-up, overrun or over-speed hazards	X	X			X
5.9	Specific requirements resulting from variation in the rotational speed of tools hazards	X	X			X

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Table 4 *(continued)*

(Sub) clause	Item	Verification method				
		Visual inspection	Functional test	Measurement	Calculation	Documentation
5.10	Specific requirements resulting from failure of the power supply hazards	X	X			X
5.11	Specific requirements resulting from failure of the control circuit hazards	X	X			X
5.12	Specific requirements resulting from errors of fitting hazards	X	X			X
5.13	Specific requirements resulting from ejected fluids or objects hazards	X	X		X	X
5.13.1	General requirements	X	X		X	X
5.13.2	Guards for large vertical Group 3 machines (NC turning machines and turning centres)	X	X		X	X
5.13.3	Guards for large horizontal Group 3 machines (NC turning machines and turning centres)	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
6	**Information for use**					
6.1	Marking	X				X
6.2	**Instruction for use**					
6.2.1	General	X	X			X
6.2.2	Tooling	X	X			X
6.2.3	Workpiece clamping	X	X			X
6.2.4	Machine functions accessible from the NC panel	X	X			X
6.2.5	Restart	X	X			X
6.2.6	Noise	X	X			X
6.2.7	Ancillary handling devices	X	X			X
6.2.8	Residual risks to be addressed by the machinery user	X	X			X
6.2.9	Installation instructions for the turning machine	X	X			X
6.2.10	Cleaning instruction for the machine	X	X			X

6 Information for use

NOTE See ISO 12100:2010, 6.4.

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6.1 Marking

Turning 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:

   — the business name and full address of the manufacturer and, where applicable, the authorized representative;

   — the designation as "turning machine", the series or type of machine and the turning machine group and size it conforms to;

   — the serial number, if any;

   — the year of construction, that is the year in which the manufacturing process is completed.

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

c) for its safe use:

   — the maximum permissible spindle speed of the spindle(s), in rotations per minute;

   — the maximum permissible chuck speed, in rotations per minute, except when integral bar clamping collets or power-operated chucks in accordance with ISO 16156 are used;

   — on horizontal machines or machines designed for bar work where it is possible to extend workpiece material or bar stock beyond the rear end of the spindle or bar feed device, an appropriate warning sign shall be provided to warn of the whipping hazard and the rear end of the machine or bar feed system shall be guarded;

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

   — the machine shall be provided with an appropriate marking, if a fire and/or explosion risk exists. The marking shall also indicate how to extinguish the fire.

6.2 Instruction for use

6.2.1 General

An instruction handbook in accordance with ISO 12100:2010, 6.4.5, completed with the specific information for the stated turning 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 staff 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 operation for which the turning machine is suited. If the machine provides Mode 2 (setting mode) and/or service mode, the details of the intended use of these modes have to be defined:

   1) the foreseeable misuse;

   2) possible residual risks, e.g. through any provided mode of operation (e.g. Mode 0, 1, 2 or service mode);

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3) the necessary qualification of operators, in particular if the machine enables the modes of operation setting and/or manual mode and/or service mode, which, for example, can require experience in:

   — adjusting and clamping of workpieces and devices,

   — setting, operating and monitoring of turning machines,

   — selection, use and mounting of tools,

   — data input for the machining of workpieces and optimization of the machining process,

   — specific hazards and required safety measures, and

   — use of personal protective equipment.

NOTE In service mode, even additional skills can be necessary (see 6.2.8).

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

c) a requirement for installation (if relevant, also recommendations on means to prevent access to chip discharge area);

d) a requirement for maintenance, including a list of those devices which shall be inspected or tested, how frequently and by what method;

e) the frequency of visual inspections that are necessary to ensure the protective function of vision panels, including the details of:

   1) inspection methods and a description of defects which make the vision panel unsuitable for continued use or indicate that replacement is required. This information may include descriptions of unacceptable vision panel 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 vision panels are dangerous as soon as they are tarnished or discoloured (see Annex B) and they have to be replaced with new vision panels before that happens;

   2) the manufacturer's recommendations for the replacement of vision panels shall take into consideration the material properties of the vision panel in question. For the special case of polycarbonate, see Figure B.2;

   3) the recommended methods for cleaning vision panels without causing damage and, where appropriate, the selection and use of suitable cleaning agents;

   4) a requirement that when changing vision panels, the assembly instructions of the machine manufacturer shall be followed;

   5) the supplier's recommended method for cleaning polycarbonate panels without causing damage;

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 cutting fluids and precautions against their degradation;

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j) recommendations on the measures to prevent spillage of cutting fluids, e.g. cleanliness of collecting gutters;

k) the instructions to enable the release of trapped persons;

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

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

n) the recommendation to use additional precautions when working with flammable metalworking fluids or pyrophoric material;

o) the recommendations of the manufacturer of the metalworking liquid which shall be followed, especially the recommendations related to the viscosity and the flashpoint of the liquid, if the machine is designed for the use of combustible metalworking fluids;

p) the prohibition of use of an emery cloth with the hand;

q) a clear warning shall be provided regarding the whipping hazard (see ISO 12100) for all horizontal machines on which it is possible to extend the bar material outside of the enclosing guards and support.

6.2.2 Tooling

a) Information to enable tools to be selected, fitted and/or changed shall be provided, e.g. data relevant to that part of the tool/machine interface belonging to the machine.

b) Where applicable, recommendations on tools to be used with the machine shall be provided, e.g. pre-set tools including, where applicable, limits of mass, moment of inertia and spatial envelope for tools in tool changing devices.

c) Information shall be provided to warn the operator that tools can be hot following machining.

6.2.3 Workpiece clamping

The following information about workpiece clamping and workpiece clamping devices shall be supplied:

a) for workpiece clamping devices supplied with the machine, information about how the workpiece clamping device shall be used and maintained (e.g. maintenance and lubrication schedule);

b) for workpiece clamping 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 clamping device manufacturer;

c) for replacing/changing the workpiece clamping device, information to enable workpiece clamping 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 clamping device modifications:

   1) information that modification of workpiece clamping 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 that workpiece clamping devices shall only be modified within the limits given by the turning machine manufacturer and in accordance with the clamping device manufacturer's recommendations;

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3) information on equipment added to or substituted for workpiece clamping 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.

6.2.4 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.

6.2.5 Restart

Information shall be provided on restart procedures. In particular, after chuck exchange, the machine setter shall enter the maximum work holding device speed. After each program change, the operator shall enter and/or validate the maximum working speed and both speeds shall be validated by the operator.

The operator shall enter and/or validate the maximum working speed for the particular workpiece and the maximum work holding device speed (see 3.5.1).

6.2.6 Noise

The following information on airborne noise emissions 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 sound pressure value at workstations, where this exceeds 63 Pa [130 dB(A) 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 a 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.

Another example for a noise declaration can be found in ISO 230-5:2000, Annex E.

NOTE The operating modes mentioned in the example from ISO 230-5 are only general and do not represent the modes of operation for turning machines according to definitions 3.3.1 to 3.3.4 of this International Standard.

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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 work room 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".

Information on noise emission should also be provided in the sales literature.

6.2.7 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.

6.2.8 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 the vision panels shall be provided.

Advice shall be provided stating 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 may affect safety functions.

Information shall be provided to indicate that machining unbalanced workpieces may 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 operation for which the turning machine is suited.

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

If the machine provides service mode in accordance with 5.2.4.5, the manufacturer of the machine shall specify:

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

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

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

For horizontal spindle turning machines that may be equipped with a bar feed device where it is possible to extend bar material outside the enclosing guard and supports, the bar feed mechanism shall bear a visible warning sign against whipping hazards (see ISO 12100:2010, 6.4.4).

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

— tool selection,

— work/tool clamping, and

— maintenance.

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6.2.9 Installation instructions for the turning 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.

6.2.10 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.

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Annex A
(normative)

Impact test method for guards on turning machines

A.1 General

This annex defines tests for guards used on NC turning machines and centres, in order to minimize risks of ejection of parts or of workpieces out of the work zone. This annex applies to guard materials as well as to complete guards for NC turning machines and centres.

A.2 Test method

A.2.1 Principle

This test method applies to machines oufitted with chucks with standard hard top jaws, and reproduces the hazard of the ejection of top jaws. The test shows the resistance/strength of guards and/or guard materials against penetration and dislodgement. The test method is based on machines equipped with standard chuck jaws driven up to the maximum speeds given in Table A.2. If the mass of top jaw or the peripheral speed exceeds the values given in Table A.2, the test conditions shall be adapted accordingly. When using one-piece jaws, the total mass of this jaw is decisive.

A.2.2 Apparatus

A.2.2.1 Propulsion device, allowing the projectile to accelerate to ±5 % of a pre-set impact speed [see Table A.2 and Formula (A.1)].

A.2.2.2 Projectile, of shape, mass and dimensions as given in Figure A.1 and Table A.1, made from steel with the following mechanical properties:

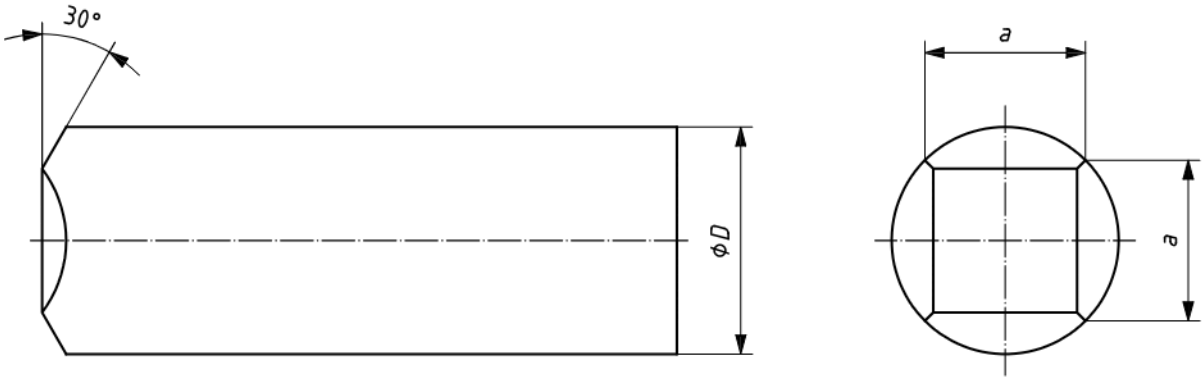
— tensile strength R_m = 560 N/mm^2 to 690 N/mm^2

— yield strength $R_{0,2} \geq 330$ N/mm^2

— elongation at rupture $A \geq 20$ %

A.2.2.3 Support, for the guard to be tested.

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

Figure A.1 — Projectile

A.2.3 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 shall be measured over a fixed distance using proximity sensors, photoelectric cells or other equivalent means.

Table A.1 — Projectile mass and dimensions

Mass kg	**Diameter** mm	**Front face** $a \times a$ mm × mm
0,625	30	19 × 19
1,25	40	25 × 25
2,5	50	30 × 30

A.2.4 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 may 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.

A.2.5 Test procedure

In order to evaluate the resistance class of a guard, a projectile shall 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. For machines equipped with chucks with standard top jaws, the impact test shall be executed with projectiles, the mass, dimensions and impact speed of which follow Table A.2, such that the projectile mass corresponds to the mass of the standard top jaw.

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A.3 Test results

A.3.1 Damage

After the impact, any damage found on the guard or material shall be assessed as follows, and they may consist of:

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.

A.3.2 Assessment

The test is passed if the damage is one of the types described in A.3.1 a) and/or b). The test is considered failed if any damage described in A.3.1 c), d), e) or f) occurs.

A.4 Test report

The test report shall specify, as a minimum, the following information:

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

b) the projectile mass, dimensions and speed;

c) the machine manufacturer, type, maximum turning diameter, maximum spindle speed, mass and dimensions of the chuck jaw;

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

e) the clamping or fixing of the test object;

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

g) the test result.

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A.5 Determination of resistance class

A.5.1 Method of determination

The resistance class (A_1 to C_3) is determined by calculating the impact speed [see Table A.2, footnote b)] using Formula (A.1):

$$v_i = 1{,}25 \times \pi \times B \times \frac{n}{60} \quad \text{(A.1)}$$

where

v_i is the impact speed, in metres per second;

1,25 is the safety factor;

B is the diameter of the work holding device, in metres;

n is the rotational speed, in rotations per minute.

The required resistance classes are determined only by the diameter of the work holding device and the according peripheral speed. The mass of the projectile, the impact speed and the impact energy of the impact test are derived according to Table A.2, where the impact speed is selected 25 % higher than the peripheral speed, because of a possible acceleration effect in the slot of the base plate of the chuck. An impact test follows in order to prove whether a resistance class is achieved.

The projectile shall be selected according to Table A.1 such that it fits to the mass of the standard top jaws of the machine in question or that it approximates it from the safe side. It shall be shaped as shown in Figure A.1 with the length and front face according to Table A.1 (see diameter and front face). This projectile shall be accelerated to the impact speed [see Table A.2, footnote b)] and shot against a material sample or a real element of the machine guards (e.g. with a gun as shown in Figure B.1). In doing so, the material sample or the guard element will either be penetrated or will withstand (although it might be deformed).

A.5.2 Interpretation of the impact test results

a) For machines equipped with chucks with standard top jaws, nine resistance classes from A_1 to C_3 are defined (see Table B.1), taking into account the mass, dimensions and foreseeable impact speed of an ejected standard top jaw (see Table A.2). The resistance classes are basically determined by the diameter of the work holding device and the corresponding peripheral speed, however, if the combination of diameter and the peripheral speed at a real machine are not similar to those in Table A.2, the impact energy column can be calculated in accordance with Formula (C.1), where the impact speed is assumed to be 25 % higher than the peripheral speed (acceleration effect due to slot in base plate of the chuck). The required resistance class is therefore that determined by the work holding device diameter, the impact speed and the real mass of a jaw, e.g. if the diameter is B = 254 (mm) and maximum rotational speed is n = 3 500 min^{-1}, the peripheral speed, in metres per second, is calculated using Formula (A.2):

$$v_p = \pi \times B \times n = 46{,}55 \quad \text{(A.2)}$$

and the impact speed, in metres per second, is calculated using Formula (A.3):

$$v_i = 1{,}25 \times 46{,}55 = 58{,}19 \quad \text{(A.3)}$$

Thus, with the mass of the standard top jaws being m = 1,21 kg, the impact energy, in joules, is calculated using Formula (A.4):

$$J_c = 0{,}5 \times 1{,}21 \times (58{,}19)^2 = 2\,048{,}66 \quad \text{(A.4)}$$

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The corresponding resistance class can be determined from Table A.2. If in the impact energy column no corresponding value of the impact energy, J_C, exists, then the next higher value in this column shall be taken to determine the resistance class. Consequently, the minimum required resistance class is B_2 (because A_3 is too small) and B_2 can be achieved with 8 mm thick polycarbonate (Table B.1).

b) For machines equipped with collets, the resistance classes A_1 to C_3 are also applicable and the impact energy shall be calculated in accordance with Formula (C.2) and Figure C.1, i.e. direct impact energy without acceleration effect due to slot in base plate (impact speed equals peripheral speed). The result shall be compared to the impact energy in Table A.2. The required resistance class is therefore that of the next higher impact energy [see example in A.5.2 a)].

c) A resistance class is regarded as having been achieved if the material sample or the guard element is not penetrated by the projectile impact. Table B.1 shows a collection of results of the impact testing in Sankt Augustin and Berlin in Germany, which can be used by the manufacturer in order to save him from having to carry out his own impact tests.

A.5.3 Conclusion

One important conclusion of these impact tests is that the translational energy of ejected standard top jaws is the most significant parameter for the dimensioning of the guards, because it was found that the rotational energy of workpieces with a maximum chuck clamping diameter and a length to diameter ratio of l/d = 1 can at most be transformed during an ejection into a maximum translational energy, which is lower than the translational energy of ejected standard top jaws. If the length to diameter ratio l/d is higher than 1, the impact energy can be calculated using Formula (C.2) and a resistance class shall be required accordingly. This situation is different from long workpieces, which are clamped between the chuck and the tailstock. Here it is assumed that their rotational energy, which is less dangerous for the operator than translational energy as such, can only to a small degree be transformed into translational energy. This is all the more the case since a stationary support might be used in order to fix long workpieces in the middle. For special machining operations, such as machining of camshafts, the potential impact situations have to be analysed separately; Annexes A to C provide useful information for this analysis.

Table A.2 — Resistance class

Work holding device diameter mm		Peripheral speed	Projectile dimensions	Projectile mass	Impact speed[a]	Impact energy[b]	Resistance class
from	up to	m/s	$D \times a$ mm	kg	m/s	J	
	<130	25	30 × 19	0,625	32	310	A_1
		40			50	781	A_2
		63			80	2 000	A_3
130	<260	40	40 × 25	1,25	50	1 562	B_1
		50			63	2 480	B_2
		63			80	4 000	B_3
260	≤500	40	50 × 30	2,50	50	3 124	C_1
		50			63	4 960	C_2
		63			80	8 000	C_3

[a] The impact speed is assumed to be 25 % higher than the peripheral speed (safe estimate), because in cases of breakage of clamping elements of the chuck, it can happen that the jaws are not only ejected from their clamping position, but that they are accelerated in the base plate slots of the chuck in outside direction, before they are ejected.

[b] For the calculation of impact energy, see Annex C.

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Annex B
(informative)

Test equipment for impact test and examples of materials

B.1 Gun

The gun consists of a compressed air vessel with a flanged gun barrel (see Figure B.1). Compressed air may be released by a valve to accelerate the projectile towards the test object.

The air gun is fed by an air compressor. The speed of the projectile may be controlled by the pressure of the air.

Projectile speed is measured near the muzzle of the gun barrel by a suitable velocimeter, e.g. using proximity sensors or photoelectric cell.

B.2 Example of materials

The following materials have passed the tests for the impact resistance classes according to Table A.2 (impact of projectile at the centre of the plate).

Table B.1 — Examples of materials

Material	Thickness d mm	Tensile strength R_m N/mm²	Elongation at rupture A %	Impact resistance class								
				A_1	A_2	A_3	B_1	B_2	B_3	C_1	C_2	C_3
Steel sheet	2	370	28	+	+	–	–	–	–	–	–	–
	2,5	370	28	+	+	–	+	–	–	+	–	–
	3	400	28	+	+	–	+	+	–	+	–	–
	4	340	25	+	+	+	+	+	+	+	+	–
	5	300	40	+	+	+	+	+	+	+	+	–
	6	340	25	+	+	+	+	+	+	+	+	+
Al Mg 3	5	240	18	+	+	–	+	–	–	+	–	–
Polycarbonate	6	68	80	+	+	–	+	–	–	–	–	–
	8	68	80	+	+	–	+	+	–	+	–	–
	10	68	80	+	+	+	+	+	–	+	+	–
	12	68	80	+	+	+	+	+	–	+	+	–
Polycarbonate compound	2 × 8	68	80	+	+	+	+	+	+	+	+	–
	2 × 12	68	80	+	+	+	+	+	+	+	+	+
	19	68	80	+	+	+	+	+	+	+	+	+
Safety glass + polycarbonate compound	Glass + PC 6 + 18			+	+	+	+	+	+	+	+	+

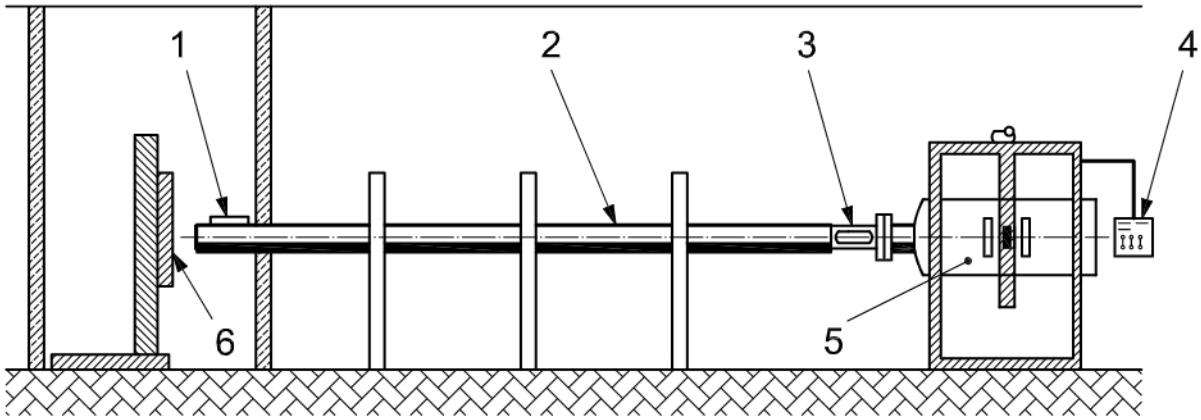
\+ Requirements fulfilled.

– Requirements not fulfilled.

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The “requirements fulfilled” notation in Table B.1 indicates only the impact resistance. If the impact resistance is reached only by means of PC-plates, the manufacturer shall ensure protection against abrasion and ageing by mean of additional measures (e.g. compound design with sealed edges).

The resistance of the guards and/or vision panels is not only dependent on the dimensioning of steel sheets and plates but also on the mounting of the vision panels in the guard and the fixing of the guard on the machine. The polycarbonate panels should overlap the frame sufficiently in order to avoid that they are pushed through the frame during an impact event. Test points for a 450 mm × 450 mm window and an attached PC sample have shown that for 8 mm PC, at least 40 mm overlapping is necessary, and for 12 mm PC, at least 25 mm overlapping, in order to retain the polycarbonate pane in its frame. If the window aperture is of a size greater or smaller than 450 mm × 450 mm, the overlapping shall be increased or decreased accordingly.

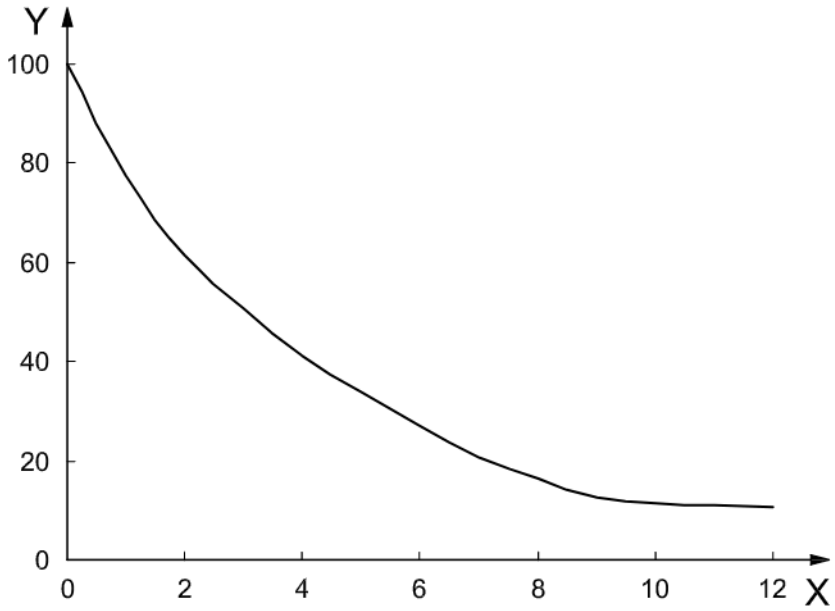


Key

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

Figure B.1 — Equipment for impact test

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Key

X time of use, expressed in years

Y impact resistance, expressed as a percentage

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.

Figure B.2 — Ageing curve of unprotected polycarbonate (averaged test points) (Source: Reference [33])

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Annex C
(informative)

Calculation of direct impact energy

The impact energy, J_c, expressed in joules, is calculated using Formulae (C.1) and (C.2):

a) For turning machines equipped with chuck, use Formula (C.1):

$$J_c = \frac{m \times v_i^2}{2} \quad \text{(C.1)}$$

where

m is the mass of standard hard top jaw, in kilograms;

v_i is impact speed calculated using Formula (A.1).

b) For turning machines equipped with collets, the impact energy, J_c, expressed in joules, is calculated using Formula (C.2):

$$J_c = \frac{\rho \times \pi^3 \times d^2 \times l^3 \times \left(\frac{n}{60}\right)^2}{24} \quad \text{(C.2)}$$

where

ρ is the specific mass, in kilogram per cubic metre;

d is the maximum bar diameter, in metres;

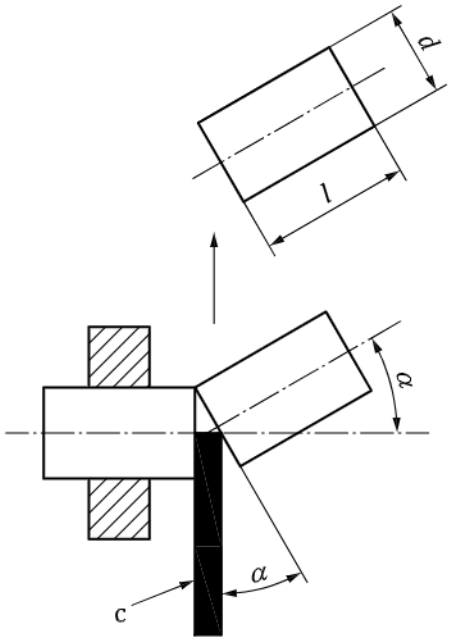
l is the maximum length of the workpiece, in metres;

n is the maximum work holding spindle speed, in revolutions per minute.

Formula (C.2) assumes direct impact at ejection of a bar section (with $\frac{d}{l} \leq 0{,}2$) breaking at $\alpha = 30°$ from the axis of rotation on a machine equipped with a collet.

NOTE This calculation is application-specific and for guidance only. Manufacturers can state limitations on maximum diameter and length of workpiece when using a collet chuck.

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Key

d	workpiece diameter [see Formula (C.2)]	c	cut-off tool blade
l	workpiece length [see Formula (C.2)]	α	breaking angle

Figure C.1 — Explanation of the workpiece behaviour

c) Processes other than turning:

If milling, grinding or other processes can occur, see EN 12417 and EN 13128 for recommendations on milling, and EN 13218 for grinding.

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Annex D
(informative)

Example of checklist for safety functions

This annex explains the relationship between parts of a particular machine and the safety concepts involved. This annex refers to safety rules, which can also apply to other types of machines; it therefore can be worthwhile for a given family of machines and with a view to a possible inspection of the safety functions(see Table D.1), to provide a list of the authorized or prohibited operations depending on the selected operating mode and the position of the movable guard (see Table D.2) again.

Table D.1 — Inspection of safety functions

Position of the mode selection device	Mode 1 (automatic mode)	Situation of movable guard			
		Closed	Open	Conditions for opening	Reclosed
Mode 1 (automatic mode)	Manual and single block	Machine functions operational. Safety devices active.	Spindle cannot be started. Part or Tool Handling Equipment (PTH) movements cannot be started. Axes movements cannot be started. Turret cannot be indexed. Error code if cycle start is commanded. Chuck and tailstock can be operated.	Spindle is stopped. PTH movements are stopped. Axes movements are stopped. Turret indexing is stopped. Coolant is off.	No operations are automatically restarted. Machine functions are operational in manual or single block mode after reset of safety devices.
	Auto and single block	Machine functions operational. Safety devices active.	Spindle cannot be started. PTH movements cannot be started. Axes movements or automatic cycle cannot be started. Error code if cycle start is commanded. Chuck and tailstock can be operated.	Cycle stop is obtained. Spindle is stopped. Spindles of driven tools are stopped. PTH movements are stopped. Axes movements are stopped. Turret indexing is stopped. Coolant is off.	No operations are automatically restarted. Machine functions are operational in automatic mode after reset of safety devices.

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Table D.1 *(continued)*

Position of the mode selection device	Mode 1 (automatic mode)	Situation of movable guard			
		Closed	Open	Conditions for opening	Reclosed
Mode 2 (setting mode)	Manual and single block or dry run cycle	—	The following functions are operable in combination with safety devices: reduced spindle speed; PTH movements with reduced velocity only; axes movements with reduced axis speed only in incremental movement; turret indexing. In addition, the following functions are allowed: operation of chuck, tailstock or work holding device; coolant on/off.	Reduced spindle and reduced axis speeds. PTH are controlled and monitored. Hold-to-run control or enabling device plus start control are required for operation.	—
—	Auto and single block or dry run cycle	Same conditions as for production mode	Same conditions as for production mode	—	—

Table D.2 — Clamping control of chuck

Position of the mode selection device	Situation of chuck or work holding device			
	Open	Closed	Workpiece in chuck	Jaw exchange position
Mode 2 (setting mode)	Spindle cannot be started	Spindle can be started	Spindle can be started	Spindle cannot be started
Mode 1 (automatic mode)	Spindle cannot be started	Spindle cannot be started	Spindle can be started	Spindle cannot be started

For special chucks, see instructions provided by the supplier or the manufacturer.

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Annex E
(informative)

Examples of exhaust and extinguishing systems

Monitoring of the coolant supply and the exhaust system is essential for the safe functioning of the machine. Coolants with oil content above 15 % can cause a risk of fire or explosion.

The safety measures after fire detection depend on the kind of exhaust system (central or local):

a) for a central automatic exhaust system

   1) the machining process should be stopped immediately (with or without controlled tool retraction),

   2) flame penetration should be suppressed by means of a closing flap or valve shutter device (see Figure E.3), since it cannot be avoided that ignition particles reach the pipes of the exhaust system,

   3) the extinguishing system should be started immediately,

   4) the coolant supply should be stopped, and

   5) the central exhaust system can continue its operation.

b) for the local exhaust system (attached to the machine)

   1) the machining process should be stopped immediately (with or without controlled tool retraction),

   2) the exhaust system should be stopped immediately,

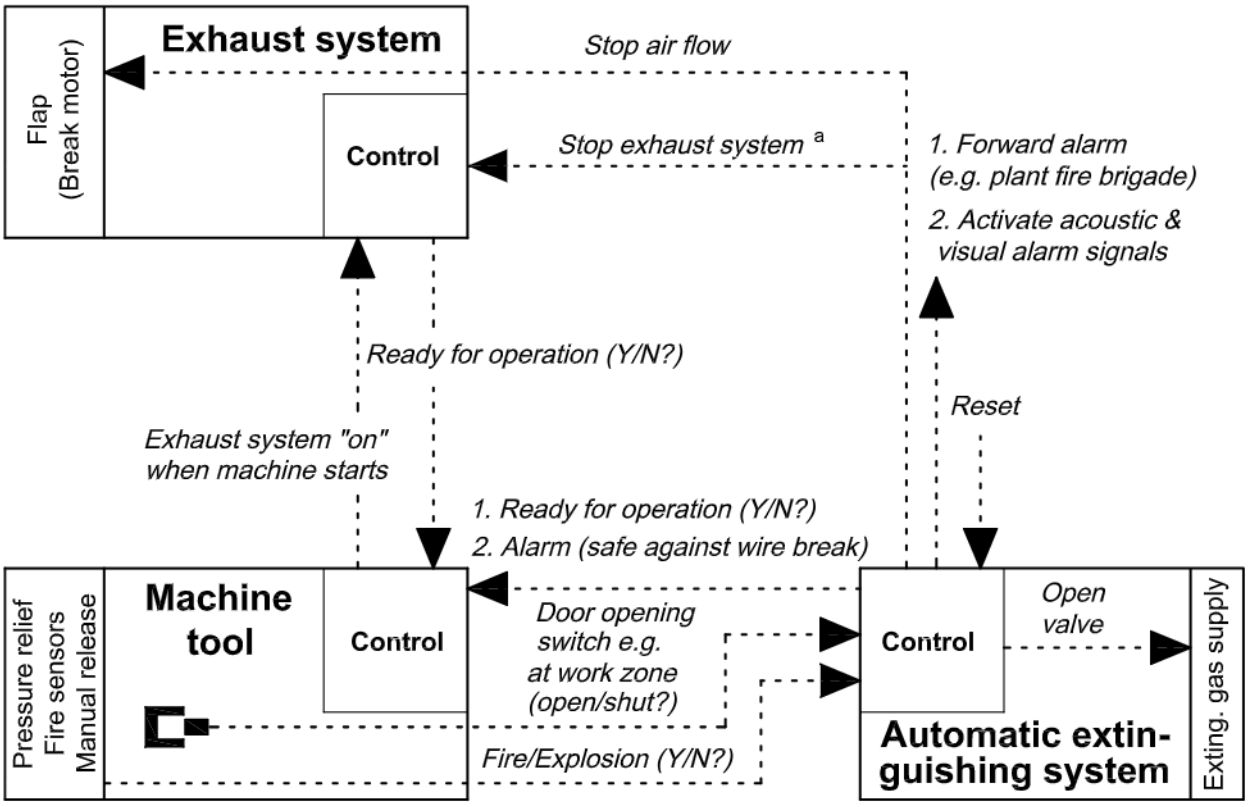
   3) the extinguishing system should be started immediately, and

   4) the coolant supply should be stopped.

NOTE These safety measures for risk of fire are not sufficient for machining flammable materials, such as magnesium or titanium. For this type of material, special measures are applied.

In order to implement the above safety functions, the controls of the turning machine, the exhaust system and the extinguishing system need to have interfaces (see Figure E.1). The responsibilities of the manufacturer and the user should be shared, as shown in Figures E.2 and E.3.

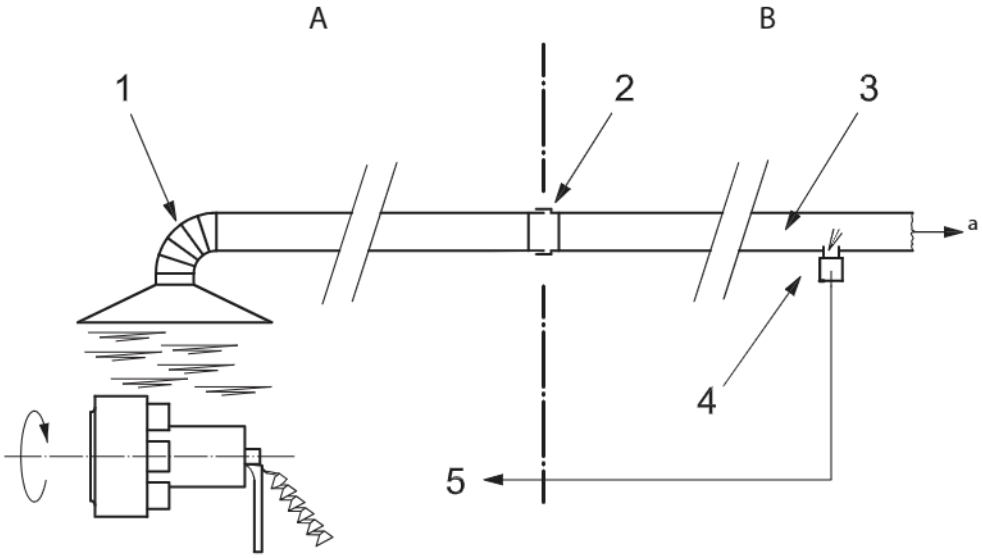
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a Only for machine-mounted exhaust system.

Figure E.1 — Example of the interaction between the turning machine control and the control of a fire extinguishing system

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Key

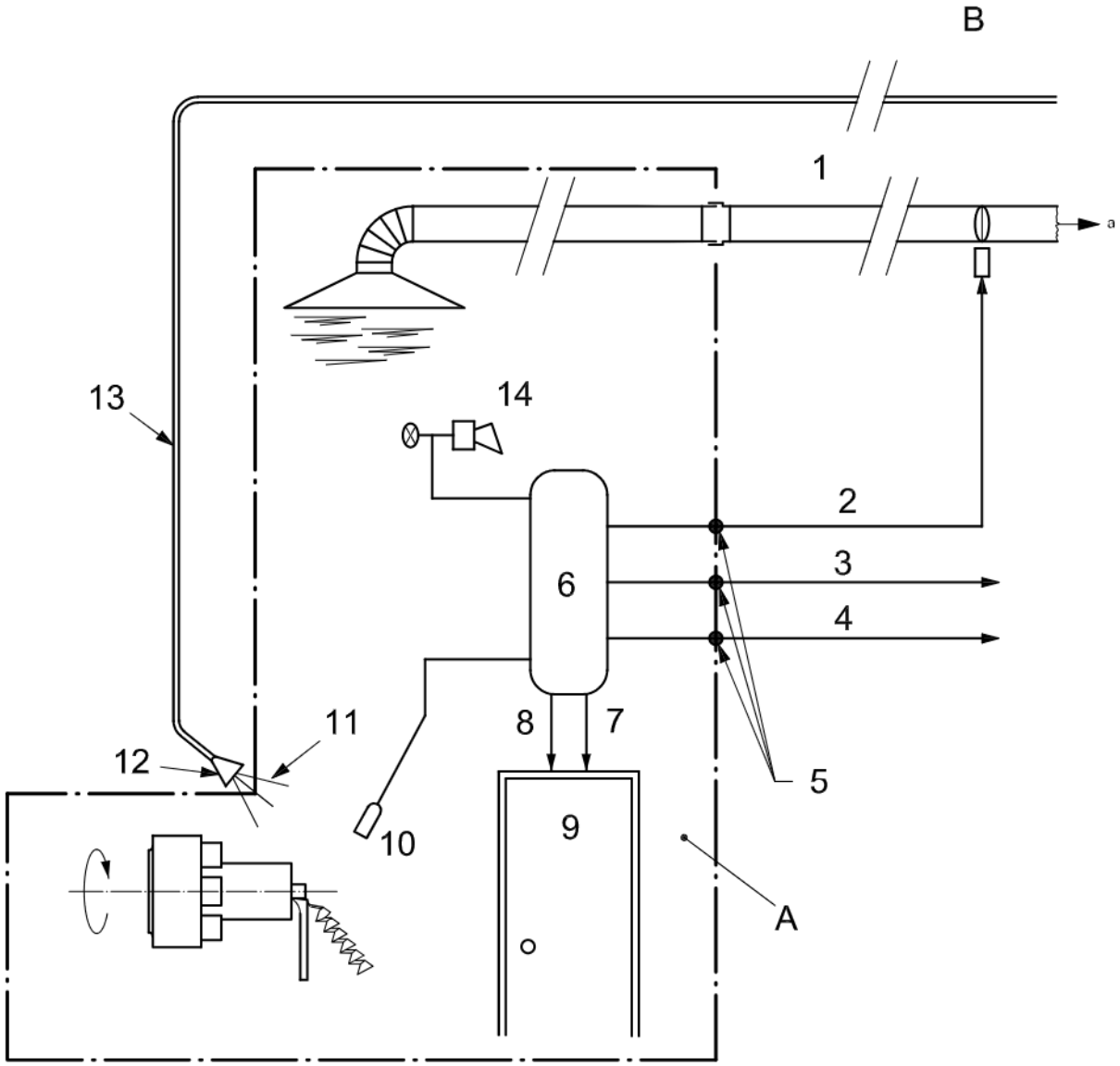
1	fume extraction device	5	signal to prevent machining if insufficient airflow
2	connection device	A	manufacturer
3	fume exhaust system	B	user
4	airflow sensor		

If explosive material or mixtures exist inside the exhaust system (e.g. from other processes), the connection of the turning machine exhaust system to a central exhaust system shall not be allowed.

[a] Air aspiration.

Figure E.2 — Example of an interface between a turning machine and an exhaust system

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Key

1	fume exhaust system	8	stop machining signal
2	valve shutter device (barrier)	9	electronic cabinet (generator)
3	extinguisher(s) triggering	10	fire detector
4	remote fire alarm	11	mist spray outlet
5	alarm outputs	12	nozzle
6	fire detection device	13	extinguishing medium
7	fire detection device OK	14	local fire alarm
A	manufacturer	B	user
a	Air aspiration.		

Figure E.3 — Example of an interface between a turning machine and an automatic extinguishing system

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Annex F
(informative)

Example of the determination of performance level for interlocked guard

F.1 General

This annex demonstrates the use of the methods of ISO 13849-1 to identify safety functions and determine performance level (PL). The quantification of a widely used control circuit is shown. The stepwise procedure consists of the following steps.

— Identification of the safety functions to be performed by safety-related parts of the control system (SRP/CS). For each safety function perform the following steps:

  — specification of the required characteristics;

  — determination of the required performance level, PL_r;

  — design and technical realization of the safety function; identification of the safety-related parts which carry out the safety function;

  — evaluation of the performance level, PL, considering

    — quantifiable aspects: category, reliability of components ($MTTF_d$), diagnostic coverage of tests (DC), measures to avoid common cause failures (CCF),

    — non-quantifiable, qualitative aspects which affect the behaviour of the SRP/CS (behaviour of the safety function under fault conditions, safety-related software, systematic failure and environmental conditions);

  — verification of the PL for the safety function (is PL greater or equal to PL_r?);

  — validation (have all the requirements been met?).

The evaluation of the PL, considering non-quantifiable aspects and the validation, are not given in this annex.

F.2 Safety function and required performance level

The chosen example of a safety-related control circuit (see Figure F.1) performs the safety function of the interlocking of the guard door, which may be chosen as follows.

The dangerous movement will be stopped when the guard door is opened (stop category 1 in accordance with IEC 60204-1; SS1, safe stop 1 in accordance with IEC 61800-5-2).

For the application of the risk graph method, the definition of risk parameters of ISO 13849-1:2006, Annex A, is inserted.

F.2.1 Severity of injury, S1 and S2

In estimating the risk arising from a failure of a safety function, only slight injuries (normally reversible), serious injuries (normally irreversible) and death are considered. To make a decision, the usual consequences of accidents and typical healing processes should be taken into account in determining

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S1 and S2. For example, bruising and/or lacerations without complications would be classified as S1, whereas amputation or death would be S2.

F.2.2 Frequency and/or exposure times to hazard, F1 and F2

The frequency parameter should be chosen according to the frequency and duration of access to the hazard. A generally valid time period to be selected for parameter F1 (infrequent) or F2 (frequent) cannot be specified. However, the following explanation could facilitate making the right decision where doubt exists. F2 should be selected if a person is frequently or continuously exposed to the hazard. It is irrelevant whether the same or different persons are exposed to the hazard on successive exposures, e.g. for the use of lifts. Where the demand on the safety function is known by the designer, the frequency and duration of this demand can be chosen instead of the frequency and duration of access to the hazard. In ISO 13849-1, the frequency of demand on the safety function is assumed to be more than once per year. The period of exposure to the hazard should be evaluated on the basis of an average value which can be seen in relation to the total period of time over which the equipment is used. For example, if it is necessary to reach regularly between the tools of the machine during cyclic operation in order to feed and move workpieces, then F2 should be selected. If access is only required from time to time, then F1 should be selected.

If there is no other justification, F2 should be chosen if the frequency is higher than once per hour.

F.2.3 Possibility of avoiding the hazard, P1 and P2

It is important to determine whether a hazardous situation can be recognized and avoided before leading to an accident. For example, an important consideration is whether the hazard can be directly identified by its physical characteristics, or recognized only by technical means, e.g. indicators. Other important aspects which influence the selection of parameter P include:

— operation with or without supervision;

— operation by experts or non-professionals;

— speed with which the hazard arises (e.g. quickly or slowly);

— possibilities for hazard avoidance (e.g. by escaping);

— practical safety experiences relating to the process.

When a hazardous situation occurs, P1 (avoidance possible) should only be selected if there is a realistic chance of avoiding an accident or of significantly reducing its effect; P2 (avoidance not possible) should be selected if there is almost no chance of avoiding the hazard.

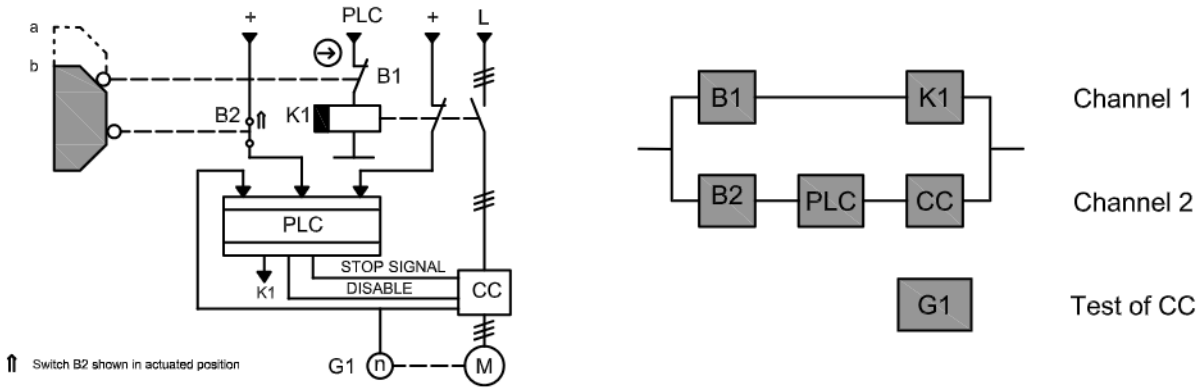
F.2.4 Required performance level

The required performance levels, PL_r, for turning machines are determined and described in 5.11 b). For the example presented in this annex (see Figure F.1), an interlocking device associated with a movable guard with access to tool changer and/or tool magazine was selected. According to 5.11 b) 1) iii), for this safety function the required performance level shall meet PL_r = d.

F.3 Identification of the safety-related parts

All components contributing to the safety function are given in Figure F.1. Functional details not contributing to the safety function of interlocking (such as start- and stop-switches or delayed switching of K1) are omitted. To demonstrate the methods of ISO 13849-1, in this example (see Figure F.1), a current converter without integrated impulse blocking is used. If integrated impulse blocking is used as an independent switch off path, the contactor K1 may eventually be omitted.

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Key

B1	position switch with separate actuator and direct opening action	CC	current converter
B2	position switch (normally open)	G1	rotation sensor
PLC	programmable logic controller	M	motor
K1	contactor		
a	Open.		
b	Closed.		

Figure F.1 — Control circuit and safety-related block diagram identifying the safety-related parts

In this example, two redundant channels providing diverse redundancy are used. The first (electromechanical) channel is made up of a type 2 position switch (normally closed) with separate actuator and direct opening action (B1) connected to a contactor (K1), with mechanically linked contact elements able to switch off the power connection to the motor. In the second channel (programmable), electronic components are used. A second position switch (normally open) (B2) with hidden placement to avoid defeating, is connected to a programmable logic controller (PLC) which can control the current converter (CC) to stop the movement of the motor (stop signal). After stopping the motor, an unexpected start-up is prevented (disable). The rotation sensor (G1), which is already there to control the speed of the motor, is also used for testing purposes.

Thus, the safety-related parts and their division into channels can be illustrated in a safety-related block diagram, as shown on the right in Figure F.1.

F.4 Evaluation of the performance level

F.4.1 General

The values for mean time to dangerous failure, $MTTF_d$, for each channel, average diagnostic coverage, DC_{avg}, and common cause factor are assumed to be evaluated in accordance with ISO 13849-1:2006, Annexes C, D, E and F, or to be given by the manufacturer. The categories are estimated in accordance with 6.2 and ISO 13849-1:2006, Annex B.

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F.4.2 Quantification of mean time to dangerous failure for each channel, average diagnostic coverage, common cause factor, category and performance level

The position switch B1 has direct opening action and a positive mode of actuation. Therefore, a fault exclusion is made concerning non-opening of a contact and non-actuation of the switch due to mechanical failure (e.g. break of plunger, wear of the actuating cam and disadjustment).

NOTE These assumptions are valid for auxiliary circuit switches in accordance with IEC 60947–5-1:1997, Annex K, and for adequate mechanical fixing and actuation of the switches according to the manufacturer's specification (see ISO 13849-2). Concerning defeating of interlocking devices, see ISO 14119.

For mean time to dangerous failure, $MTTF_d$, in the first channel, B1 and K1 are contributing to mean time to dangerous failure, $MTTF_{dC1}$. For mechanical faults of B1 (including the actuator), a B_{10d}-value of 2 000 000 cycles is assumed to be given by the manufacturer. Taking into account 365 working days per year, 16 working hours per day and one cycle every 10 minutes, this leads to a mean number of annual operations, n_{op}, of 35 040 cycles per year. $MTTF_{dB1}$ is therefore calculated using Formula (F.1):

$$MTTF_{dB1} = \frac{B_{10d}}{0{,}1 \times n_{op}} = \frac{2\,000\,000\ \text{cycles}}{0{,}1 \times 35\,040\ \text{cycles}/a} = 570a \tag{F.1}$$

For the contactor K1, the B_{10d} of 2 600 000 cycles (electrical lifetime for inductive load – AC3 – taking into account 50 % dangerous faults) is also assumed to be given by the manufacturer. With n_{op} determined as above, this leads to $MTTF_{dK1} = 742a$.

The first channel is given as Formula (F.2):

$$\frac{1}{MTTF_{dC1}} = \frac{1}{MTTF_{dB1}} + \frac{1}{MTTF_{dK1}} = \frac{1}{570a} + \frac{1}{742a} = \frac{1}{322a} \tag{F.2}$$

This leads to $MTTF_{dC1} = 322a$ for the channel which is reduced to the maximum value of $100a$ allowed for any channel.

In the second channel, B2, PLC and CC are contributing to $MTTF_{dC2}$. B2 is a position switch (normally open) with a B_{10d}-value of 1 000 000 cycles assumed to be given by the manufacturer. With n_{op} as mentioned above, the $MTTF_d$ of $285a$ is half as good as B1. For PLC and CC, $MTTF_d$-values of $50a$ are assumed to be given by the manufacturer.

The second channel is given as Formula (F.3):

$$\frac{1}{MTTF_{dC2}} = \frac{1}{MTTF_{dB2}} + \frac{1}{MTTF_{dPLC}} + \frac{1}{MTTF_{dCC}} = \frac{1}{285a} + \frac{1}{50a} + \frac{1}{50a} = \frac{1}{23a} \tag{F.3}$$

Because both channels have different $MTTF_d$, a symmetrization formula, given in Formula (F.4), can be used to calculate a substitutional value for a one-channel $MTTF_d$ of a symmetrical two-channel system:

$$\begin{aligned} MTTF_d &= \frac{2}{3}\left(MTTF_{dC1} + MTTF_{dC2} - \frac{1}{\frac{1}{MTTF_{dC1}} + \frac{1}{MTTF_{dC2}}} \right) \\ &= \frac{2}{3}\left(100a + 23a - \frac{1}{\frac{1}{100a} + \frac{1}{23a}} \right) = 69a\ (\text{"high"}) \end{aligned} \tag{F.4}$$

The rotation sensor G1 does not contribute to the $MTTF_d$.

For the estimation of DC, in the control circuit, B1, B2 and K1 are read back by the PLC, the PLC performs self-tests and the CC is read back via G1 by the PLC. The related DC-values of every tested part are:

— $DC_{B1} = DC_{B2} = 60$ % ("low"), due to cross monitoring of inputs without dynamic test;

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— DC_{K1} = 99 % (“high”), due to direct monitoring (monitoring of electromechanical devices by mechanically linked contact elements);

— DC_{PLC} = 30 % (“none”), due to low effectiveness of self-tests (it is assumed that this value is given by FMEA by the manufacturer);

— DC_{CC} = 90 % (“medium”), because of redundant shut-off path with monitoring of one of the actuators either by logic or by test equipment. If the PLC monitors a failure of the CC, it is able to stop the motion by disconnecting the electrical power supply to K1.

For an estimation of the PL, an average diagnostic coverage, DC_{avg}, is needed as input:

$$DC_{avg} = \frac{\frac{DC_{B1}}{MTTF_{dB1}} + \frac{DC_{B2}}{MTTF_{dB2}} + \frac{DC_{K1}}{MTTF_{dK1}} + \frac{DC_{PLC}}{MTTF_{dPLC}} + \frac{DC_{CC}}{MTTF_{dCC}}}{\frac{1}{MTTF_{dB1}} + \frac{1}{MTTF_{dB2}} + \frac{1}{MTTF_{dK1}} + \frac{1}{MTTF_{dPLC}} + \frac{1}{MTTF_{dCC}}} \tag{F.5}$$

$$= \frac{\frac{60\,\%}{570a} + \frac{60\,\%}{285a} + \frac{99\,\%}{742a} + \frac{30\,\%}{50a} + \frac{90\,\%}{50a}}{\frac{1}{570a} + \frac{1}{285a} + \frac{1}{742a} + \frac{1}{50a} + \frac{1}{50a}} = 61\,\%$$

For the CCF, it is assumed that a CCF estimation has been carried out in accordance with ISO 13849-1:2006, F.2. The following measures against CCF are performed (score in parentheses):

Physical separation between signal path (15), diversity (20), protection against over-voltage, over-pressure (15), prevention of contamination and electromagnetic compatibility (EMC) against CCF in accordance with appropriate standards (25), prevention of temperature, shock, vibration, humidity as a cause of common cause failures (10).

Sufficient measures against CCF require a minimum score of 65 (out of 100). Here, a score of 85 is enough to fulfil the requirements against CCF.

For category, the basic requirements of category B (design, construction, selection, assembly and combination in accordance with relevant standards to withstand the expected influence; use of basic safety principles) are fulfilled. Well-tried safety principles are used. A single fault does not lead to the loss of the safety-function. Whenever reasonably practicable, the single fault is detected. The diagnostic coverage (DC) is in the range 60 % to 90 %. CCFs are sufficiently reduced. These characteristics fulfil the requirements of category 3.

For an estimation of the PL, the input data for Figure 5 and Annex K of ISO 13849-1:2006 are the following: $MTTF_d$ for each channel is “high” (69a), DC_{avg} is “low” (61 %) and category is 3. Assuming a mission time of 20 years (see ISO 13849-1:2006, 4.5.4), this leads to a performance level “d” with an average probability of a dangerous failure of $1{,}84 \times 10^{-7}$/h.

F.5 Verification

This result matches the required performance level “d” of F.2. Therefore, the control circuit meets the requirements for risk reduction of the application example of F.2.

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