भारतीय मानक
Indian Standard

IS 17253 (Part 1) : 2024
ISO 16090-1 : 2022

मशीन टूल्स सुरक्षा — मशीनिंग केंद्र, मिलिंग मशीनें, ट्रांसफर मशीनें

भाग 1 सुरक्षा अपेक्षाएँ

(पहला पुनरीक्षण)

Machine Tools Safety — Machining Centres, Milling Machines, Transfer Machines

Part 1 Safety Requirements

(First Revision)

ICS 13.110; 25.080.01

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Machine Tools, Machine Tool Elements, and Holding Devices Sectional Committee, PGD 35

NATIONAL FOREWORD

This Indian Standard (Part 1) (First Revision) which is identical to ISO 16090-1 : 2022 'Machine tools safety — Machining centres, milling machines, transfer machines — Part 1: Safety requirements', issued by the International Organization of Standards (ISO), was adopted by the Bureau of Indian Standards on the recommendation of the Machine Tools, Machine Tool Elements and Holding Devices Sectional Committee and approval of the Production and General Engineering Division Council.

Machining centres, milling machines and transfer machines present a wide range of hazards. Protection of operators and other persons from contact with moving cutting tools, especially when being rapidly rotated in the spindle or being swung from a tool magazine to the spindle during power-operated tool changing, or from contact with fast–moving workpieces, is of great importance. When power-operated mechanisms are provided for workpiece transfer, they can also create hazardous situations during loading/unloading and workpiece alignment, clamping or releasing of the work piece.

The machinery concerned and the extent to which hazards, hazardous situations or hazardous events are covered are indicated in the Scope of this standard. Where requirements of this type-C standard are different from those stated in type-A or type-B standards, the requirements of this type-C standard take precedence over the requirements of the other standards for machines that have been designed and built according to the requirements of this type-C standard.

This standard was first published in 2019 based on ISO 16090-1 : 2017. This revision of this standard has been undertaken to align it with the latest version of ISO 16090-1.

The major changes have been incorporated in this revision are as follows:

a) Updation and addition of safety functions in Annex J;
b) Revision of operating modes and change of designation from MSO (mode of safe operation) to MO (mode of operation); and
c) Former MSO 3 (optional special mode for manual intervention under restricted operating conditions), in the current addition referred to as MO 3 (manual intervention under restricted operating conditions), has been revised in a way, that the usage of an enabling device is necessary in any case, that is dispensing of the enabling device is no longer possible.

The text of ISO standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'; and
b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this standard, references appear to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards, which are to be substituted in their respective places, are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 230-5 : 2000 Test code for machine tools — Part 5: Determination of the noise emission	IS 2063 (Part 5) : 2016/ISO 230-5 : 2000 Test code for machine tools: Part 5 Determination of the noise emission	Identical

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 4413 : 2010 Hydraulic fluid power — General rules and safety requirements for systems and their components	IS 10481 : 2020/ISO 4413 : 2010 Hydraulic fluid power — General rules and safety requirements for systems and their components (*second revision*)	Identical
ISO 4414 : 2010 Pneumatic fluid power — General rules and safety requirements for systems and their components	IS 12725 : 2021/ISO 4414 : 2010 Pneumatic fluid power — General rules and safety requirements for systems and their components (*second revision*)	Identical
ISO 4871 : 1996 Acoustics — Declaration and verification of noise emission values of machinery and equipment	IS/ISO 4871 : 1996/ISO 4871 : 1996 Acoustics — Declaration and verification of noise emission values of machinery and equipment	Identical
ISO 9355-2 : 1999 Ergonomic requirements for the design of displays and control actuators — Part 2: Displays	IS 16563 (Part 2) : 2017/ISO 9355-2 : 1999 Ergonomic requirements for the design of displays and control actuators: Part 2 Displays	Identical
ISO 9355-3 : 2006 Ergonomic requirements for the design of displays and control actuators — Part 3: Control actuators	IS 16563 (Part 3) : 2017/ISO 9355-3 : 2006 Ergonomic requirements for the design of displays and control actuators: Part 3 Control actuators	
ISO 12100 : 2010 Safety of machinery — General principles for design — Risk assessment and risk reduction	IS 16819 : 2018/ISO 12100 : 2010 Safety of machinery — General principles for design — Risk assessment and risk reduction	Identical
ISO 13849-1 : 2015 Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design	IS 16810 (Part 1) : 2018/ISO 13849-1 : 2015 Safety of machinery — Safety related parts of control systems: Part 1 General principles for design	Identical
ISO 13849-2 : 2012 Safety of machinery — Safety-related parts of control systems — Part 2: Validation	IS 16810 (Part 2) : 2018/ISO 13849-2 : 2012 Safety of machinery — Safety related parts of control systems: Part 2 Validation	Identical
ISO 13850 : 2015 Safety of machinery — Emergency stop function — Principles for design	IS 16818 : 2018/ISO 13850 : 2015 Safety of machinery — Emergency stop function — Principles for design	Identical
ISO 13851 : 2019 Safety of machinery — Two-hand control devices — Principles for design and selection	IS 16817 : 2020/ISO 13851 : 2019 Safety of Machinery — Two-hand control devices — Principles for design and selection (*first revision*)	Identical
ISO 13855 : 2010 Safety of machinery — Positioning of safeguards with respect to the approach speeds of parts of the human body	IS 16815 : 2019/ISO 13855 : 2010 Safety of machinery — Positioning of safeguards with respect to the approach speeds of parts of the human body	Identical

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 13856-1 : 2013 Safety of machinery — Pressure-sensitive protective devices — Part 1: General principles for design and testing of pressure-sensitive mats and pressure-sensitive floors	IS 16835 (Part 1) : 2018/ISO 13856-1 : 2013 Safety of machinery — Pressure-sensitive protective devices: Part 1 General principles for design and testing of pressure-sensitive mats and pressure-sensitive floors	Identical
ISO 13856-2 : 2013 Safety of machinery — Pressure-sensitive protective devices — Part 2: General principles for design and testing of pressure-sensitive edges and pressure-sensitive bars	IS 16835 (Part 2) : 2018/ISO 13856-2 : 2013 Safety of machinery — Pressure-sensitive protective devices: Part 2 General principles for design and testing of pressure-sensitive edges and pressure-sensitive bars	Identical
ISO 13857 : 2019 Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs	IS 16814 : 2021/ISO 13857 : 2019 Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs (*first revision*)	Identical
ISO 14118 : 2017 Safety of machinery — Prevention of unexpected start-up	IS 16813 : 2019/ISO 14118 : 2017 Safety of machinery — Prevention of unexpected start–up	Identical
ISO 14119 : 2013 Safety of machinery — Interlocking devices associated with guards — Principles for design and selection	IS 16812 : 2018/ISO 14119 : 2013 Safety of machinery — Interlocking devices associated with guards — Principles for design and selection	Identical
ISO 14120 : 2015 Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards	IS 16811 : 2018/ISO 14120 : 2015 Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards	Identical
ISO 14738 : 2002 Safety of machinery — Anthropometric requirements for the design of workstations at machinery	IS 16572 : 2017/ISO 14738 : 2002 Safety of machinery — Anthropometric requirements for the design of workstations at machinery	Identical
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	IS 15836 (Part 1) : 2008/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	Identical
ISO 15534-2 : 2000 Ergonomic design for the safety of machinery — Part 2: Principles for determining the dimensions required for access openings	IS 15836 (Part 2) : 2008/ISO 15534-2 : 2000 Ergonomic design for the safety of machinery: Part 2 Principles for determining the dimensions required for access openings	Identical

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
ISO 15641 : 2001 Milling cutters for high speed machining — Safety requirements	IS 17025 : 2018/ISO 15641 : 2001 Milling cutters for high speed machining — Safety requirements	Identical
ISO 19353 : 2019 Safety of machinery — Fire prevention and fire protection	IS 16807 : 2020/ISO 19353 : 2019 Safety of machinery — Fire prevention and fire protection (*first revision*)	Identical
ISO 23125 : 2015 Machine tools — Safety — Turning machines	IS 17258 : 2019/ISO 23125 : 2015 Machine tools — Safety — Turning machines	Identical
IEC 60204-1 : 2016 Safety of machinery — Electrical equipment of machines — Part 1: General requirements	IS 16504 (Part 1) : 2019/IEC 60204-1 : 2016 Safety of machinery — Electrical equipment of machines: Part 1 General requirements (*first revision*)	Identical
IEC 61000-4-2 : 2008 Electromagnetic compatibility (EMC) — Part 4-2: Testing and measurement techniques — Electrostatic discharge immunity test	IS 14700 (Part 4/Sec 2) : 2018/ IEC 61000-4-2 : 2008 Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 2 Electrostatic discharge immunity test (*second revision*)	Identical
IEC 61000-4-4 : 2012 Electromagnetic compatibility (EMC) — Part 4-4: Testing and measurement techniques — Electrical fast transient/burst immunity test	IS 14700 (Part 4/Sec 4) : 2018/ IEC 61000-4-4 : 2012 Electromagnetic compatibility (EMC): Part 4 Testing and measurement techniques, Section 4 Electrical fast transient/burst immunity test (*second revision*)	Identical
IEC 61000-6-2 : 2016 Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity for industrial environments	IS 14700 (Part 6/Sec 2) : 2019/ IEC 61000-6-2 : 2016 Electromagnetic compatibility (EMC): Part 6 Generic standards, Section 2 Immunity standard for industrial environments (*first revision*)	Identical

The Committee has reviewed the provisions of the following International Standards referred in this adopted standard and has decided that they are acceptable for use in conjunction with this standard:

International Standard	*Title*
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 9355-1 : 1999	Ergonomic requirements for the design of displays and control actuators — Part 1: Human interactions with displays and control actuators
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 16156 : 2004	Machine-tools safety – Safety requirements for the design and construction of work holding chucks
IEC 60825-1 : 2014	Safety of laser products — Part 1: Equipment classification and requirements
EN 614-1+A1 : 2009	Safety of machinery — Ergonomic design principles — Part 1: Terminology and general principles
EN 1005-1+A1 : 2008	Safety of machinery — Human physical performance — Part 1: Terms and definitions
EN 1005-2+A1 : 2008	Safety of machinery — Human physical performance — Part 2: Manual handling of machinery and component parts of machinery
EN 1005-3+A1 : 2008	Safety of machinery — Human physical performance — Part 3: Recommended force limits for machinery operation
EN 1005-4+A1 : 2008	Safety of machinery — Human physical performance — Part 4: Evaluation of working postures and movements in relation to machinery

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*).’ The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Contents

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Introduction

This document is a type-C standard as stated in ISO 12100.

This document is of relevance, in particular for the following stakeholder groups representing the market players with regard to machinery safety:

— machine manufacturers (small, medium and large enterprises);

— health and safety bodies (regulators, accident prevention organisations, market surveillance, etc.).

Others can be affected by the level of machinery safety achieved with the means of the document by the above-mentioned stakeholder groups:

— machine users/employers (small, medium and large enterprises);

— machine users/employees (e.g. trade unions, organizations for people with special needs);

— service providers, e.g. for maintenance (small, medium and large enterprises);

— consumers (in case of machinery intended for use by consumers).

The above-mentioned stakeholder groups have been given the possibility to participate at the drafting process of this document.

The machinery concerned and the extent to which hazards, hazardous situations or hazardous events are covered are indicated in the Scope of this document.

When requirements of this type-C standard are different from those stated in type-A or type-B standards, the requirements of this type-C standard take precedence over the requirements of the other standards for machines that have been designed and built according to the requirements of this type-C standard.

Machining centres, milling machines and transfer machines present a wide range of hazards. Protection of operators and other persons from contact with moving cutting tools, especially when being rapidly rotated in the spindle or being swung from a tool magazine to the spindle during power-operated tool changing, or from contact with fast–moving workpieces, is of great importance.

When power-operated mechanisms are provided for workpiece transfer, they can also create hazardous situations during loading/unloading and workpiece alignment, clamping or releasing of the workpiece.

The significant hazards covered by this document are those listed in Clause 4. The safety requirements and/or protective measures to prevent or minimize those hazards identified in Table 1 and procedures for verification of these requirements or measures are found in 5.17.

Figures D.1 to D.8 are examples only and are not intended to illustrate the only interpretation of the text.

Indian Standard

MACHINE TOOLS SAFETY — MACHINING CENTRES, MILLING MACHINES, TRANSFER MACHINES

PART 1 SAFETY REQUIREMENTS

(First Revision)

1 Scope

This document specifies the technical safety requirements and protective measures for the design, construction and supply (including installation and dismantling, with arrangements for transport and maintenance) of:

— milling machines (see 3.1.1), including machines capable of performing boring operations (see 3.1.2);

— machining centres; and

— transfer machines (see 3.1.3)

designed for continuous production use, which are intended to cut cold metal and other non-combustible cold materials, except wood or materials with physical characteristics similar to those of wood as defined in ISO 19085-1 and glass, stone and engineered/agglomerated materials as defined in EN 14618.

This document covers the following machines (referred to as "machines" in this document):

a) manually, without numerical control, operated boring and milling machines (see 3.2.1, Group 1), e.g. knee and column type milling machines (see Figures C.1 and C.2);

b) manually, with limited numerical control, operated boring and milling machines (see 3.2.2, Group 2), e.g. profile and contouring milling machines (see Figures C.3 and C.4);

c) numerically controlled milling machines and machining centres (see 3.2.3, Group 3), e.g. automatic milling machines and milling centres, e.g. multi-spindle milling machines, gear-milling machines (see Figures C.5 to C.7);

d) transfer and special-purpose machines (see 3.2.4, Group 4), which are designed to process only pre-specified workpieces or limited range of similar workpieces by means of a predetermined sequence of machining operations and process parameters (see Figures C.8 to C.13).

e) machines fitted with the following devices/facilities, whose hazards have been dealt with:

— tool magazine(s);

— tool changer(s);

— workpiece handling mechanism(s);

— powered workpiece clamping mechanism(s);

— swarf/chip conveyor(s);

— power-operated door(s);

— moveable operator cabin(s);

— additional equipment for turning;

— additional equipment for grinding.

This document deals with all significant hazards, hazardous situations and events relevant to this type of machinery which can occur during transportation, assembly and installation, setting, operation, cleaning and maintenance, troubleshooting, dismantling or disabling according to ISO 12100, when the machinery is used as intended and under conditions of misuse which are reasonably foreseeable by the manufacturer (see Clause 4).

This document presumes accessibility to the machine from all directions and specifies access conditions to operator positions. It also applies to workpiece transfer devices including transport devices for loading/unloading when they form an integral part of the machine.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 230-5:2000, *Test code for machine tools — Part 5: Determination of the noise emission*

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 9355-1:1999[1)], *Ergonomic requirements for the design of displays and control actuators — Part 1: Human interactions with displays and control actuators*

ISO 9355-2:1999, *Ergonomic requirements for the design of displays and control actuators — Part 2: Displays*

ISO 9355-3:2006, *Ergonomic requirements for the design of displays and control actuators — Part 3: Control actuators*

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

ISO 13849-1:2015, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 13849-2:2012, *Safety of machinery — Safety-related parts of control systems — Part 2: Validation*

1) Now withdrawn.

ISO 13850:2015, *Safety of machinery — Emergency stop function — Principles for design*

ISO 13851:2019, *Safety of machinery — Two-hand control devices — Principles for design and selection*

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

ISO 13856-1:2013, *Safety of machinery — Pressure-sensitive protective devices — Part 1: General principles for design and testing of pressure-sensitive mats and pressure-sensitive floors*

ISO 13856-2:2013, *Safety of machinery — Pressure-sensitive protective devices — Part 2: General principles for design and testing of pressure-sensitive edges and pressure-sensitive bars*

ISO 13857:2019, *Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs*

ISO 14118:2017, *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 14120:2015, *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*

ISO 14738:2002, *Safety of machinery — Anthropometric requirements for the design of workstations at 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 15641:2001, *Milling cutters for high speed machining — Safety requirements*

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

ISO 19353:2019, *Safety of machinery — Fire prevention and fire protection*

ISO 23125:2015, *Machine tools — Safety — Turning machines*

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

IEC 60825-1:2014, *Safety of laser products — Part 1: Equipment classification and requirements*

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) — Part 4-2: Testing and measurement techniques — Electrostatic discharge immunity test*

IEC 61000-4-4:2012, *Electromagnetic compatibility (EMC) — Part 4-4: Testing and measurement techniques — Electrical fast transient/burst immunity test*

IEC 61000-6-2:2016, *Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity for industrial environments*

EN 614-1+A1:2009, *Safety of machinery - Ergonomic design principles - Part 1: Terminology and general principles*

EN 1005-1+A1:2008, *Safety of machinery — Human physical performance — Part 1: Terms and definitions*

EN 1005-2+A1:2008, *Safety of machinery — Human physical performance — Part 2: Manual handling of machinery and component parts of machinery*

EN 1005-3+A1:2008, *Safety of machinery - Human physical performance - Part 3: Recommended force limits for machinery operation*

EN 1005-4+A1:2008, *Safety of machinery — Human physical performance — Part 4: Evaluation of working postures and movements in relation to machinery*

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 General terms

3.1.1
milling machine
machine tool using geometrically defined rotary cutters to remove material in order to produce plane or formed surfaces on a workpiece while advancing (i.e. feeding) the tool or the workpiece in a certain direction (axis movement) or certain directions (axes movements)

3.1.2
boring machine
machine tool for boring holes in which the principal motion is a rotating cutter against a non-rotating workpiece along a feed axis and the diameter of the hole is adjusted by a different axis which is usually perpendicular to the feed axis

Note 1 to entry: This definition does not include machines exclusively used for drilling.

3.1.3
transfer machine
special purpose machine
machine designed to process only a pre-specified workpiece or family of workpieces, by means of a predetermined sequence of machining operations and process parameters

3.1.4
boring operation
machining process of enlarging a hole that has already been produced (e.g. drilled or cast), by means of a single-point cutting tool or a boring head which contains several such tools

3.1.5
numerical control
NC
automatic control of a process performed by a device that makes use of numeric data introduced while operation is in progress

[SOURCE: ISO 2806:1994, 2.1.1]

3.1.6
computerized numerical control
CNC
realization of *NC* (3.1.5) using a computer to control the machine functions

[SOURCE: ISO 2806:1994, 2.1.2]

3.1.7
manual data input
MDI
mode of operation of a CNC system in which the part program is generated by inputting data manually at the machine

3.1.8
electro-sensitive protective equipment
ESPE
assembly of devices and/or components working together for protective tripping or presence-sensing purposes comprising a sensing device, controlling monitoring devices, output devices and all interconnecting wiring

[SOURCE: IEC 61496-1:2012, 3.5]

3.1.9
active opto-electronic protective device
AOPD
device whose sensing function is performed by opto-electronic emitting and receiving elements detecting the interruption of optical radiation, generated within the device, by an opaque object present in the specified detection zone

Note 1 to entry: IEC 61496-2 gives detailed provisions on AOPD. For applications, see IEC/TS 62046.

3.1.10
pressure sensitive protective device
PSPD
sensor(s) that responds to the application of pressure, a control unit and one or more output signal switching device(s) and equipment for detecting persons or parts of persons which generates an appropriate signal to the control system to reduce risk to the persons detected

Note 1 to entry: ISO 13856-1, ISO 13856-2 and ISO 13856-3 give detailed provisions.

Note 2 to entry: Safety-related control system associated with the PSPD or the PSPD itself can further include a secondary switching device, start interlock, re-start interlock, etc.

3.1.11
safe operating stop
SOS
function that prevents motor from deviating more than a defined amount from the stopped position by providing energy to the motor to enable it to resist external forces

Note 1 to entry: The SOS function prevents the motor from deviating from the stop position by more than a specified value. The power drive system supplies the motor with energy so that it can withstand external forces; see also IEC 61800-5-2.

Note 2 to entry: This safety function corresponds to a controlled stop category 2 of IEC 60204-1, where torque, speed or rotation positions are maintained and monitored.

3.1.12
safe stop 1
SS1
function which:

a) initiates and controls the motor deceleration rate within set limits to stop the motor and initiates the *STO* (3.1.14) function when the motor speed is below a specified limit;

b) initiates and monitors the motor deceleration rate within set limits to stop the motor and initiates the STO function when the motor speed is below a specified limit; or

c) initiates the motor deceleration and initiates the STO function after an application specific time delay

Note 1 to entry: This safety function corresponds to a controlled stop in accordance with stop category 1 of IEC 60204-1.

3.1.13
safe stop 2
SS2
function which:

a) initiates and controls the motor deceleration rate within set limits to stop the motor and initiates the safe operating stop function when the motor speed is below a specified limit;

b) initiates and monitors the motor deceleration rate within set limits to stop the motor and initiates the safe operating stop function when the motor speed is below a specified limit; or

c) initiates the motor deceleration and initiates the safe operating stop function after an application specific time delay

Note 1 to entry: This safety function corresponds to a controlled stop in accordance with stop category 2 of IEC 60204-1.

3.1.14
safe torque off
STO
function which ensures that no energy is applied to the motor that can cause rotation or motion (in the case of a linear motor)

Note 1 to entry: The power drive system (PDS) does not provide energy to the motor which can generate torque or force (in the case of a linear motor), see also IEC 61800-5-2:2016, 4.2.3.2.

Note 2 to entry: This safety function corresponds to an uncontrolled stop in accordance to stop category 0 of IEC 60204-1.

Note 3 to entry: This safety function may be used where power removal is required to prevent an unexpected start-up.

Note 4 to entry: In circumstances where external influences (e.g. falling of suspended loads) are present, additional measures (e.g. mechanical brakes) may be necessary to prevent any hazardous situation.

Note 5 to entry: Electronic means and electric contactors are not adequate for protection against electric shock and additional measures for isolation may be necessary.

3.1.15
direction control
positive actuation device to select and maintain a movement

Note 1 to entry: A direction control can be a soft key, touch key, push button control or a rotary type button, e.g. for opening or closing a door or for a movement for clockwise or counter-clockwise.

3.1.16
non-combustible cold material
material, excluding wood, with PCS ≤ 3,0 MJ/kg (ISO 1716) or $\Delta T \leq 50$ °C and $\Delta m \leq 50$ % and $t_f \leq 20$ s (ISO 1182), which withstand surface flame attacks and edge flame attacks with 30 s exposure time without flame spread in excess of 150 mm vertically from the point of application of the test flame within 60 s from the time of application (ISO 11925-2)

3.1.17
short presence
dwelling time of a person staying in the hazard zone less than an accumulated time of 1 h, but never more than 10 min per single exposition, during an 8 h shift

3.1.18
minimum quantity lubrication
MQL
process of using a little quantity lubrication on cutting point by external spray or through-tool systems

Note 1 to entry: The amount to be used depends on the machining process and type of MQL delivery system.

Note 2 to entry: Minimum quantity lubrication is sometimes referred to as microlubrication.

3.1.19
manual reset
manual reset function
function within the SRP/CS used to restore manually one or more safety functions before restarting a machine

Note 1 to entry: Examples are to reset light curtains, open doors, etc.

3.1.20
open guard
all possible guard positions that are not fully closed

3.1.21
teleservice
machine diagnosis (including troubleshooting), software update and *telecontrol* (3.1.22) from a remote service site

3.1.22
telecontrol
control of the machine movements from a remote service site

3.1.23
emergency stop device
manually actuated control device used to initiate an emergency stop function

[SOURCE: ISO 13850:2015, 3.3]

3.2 Groups of machines

With regard to the applications and the relevant hazards, machines are subdivided into four different groups.

3.2.1
Group 1 machine: Manually controlled boring and milling machine without numerical control
machine where axis motion is controlled by actuation of a mechanical handwheel or where powered single-axis motion is controlled by mechanical, electrical or other means but without the capability for programmed multiple axes movement

Note 1 to entry: For an illustration, see Figures C.1 and C.2.

3.2.2
Group 2 machine: Manually controlled boring and milling machine with limited numerical controlled capability
machine that can be operated like a Group 1 machine by the use of mechanical or electronic handwheels or as a machine with limited NC capabilities which are not capable of automatic program start, automatic initiated tool change, unlimited rapid axis movement and automatic workpiece change or bar feed system

Note 1 to entry: For an illustration, see Figures C.3 and C.4.

Note 2 to entry: This group of machines can be equipped with some or all of the features of Group 1 machines (manual machines without NC) and a limited numeric control system (NC) that enables the machine to provide:

— a constant surface speed (CSS);

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

— thread cutting cycles.

3.2.3
Group 3 machine: Numerically controlled boring-, milling machine and machining centre
numerically controlled machine capable of performing programmed multiple axis movements

Note 1 to entry: For an illustration, see Figures C.5, C.6, and C.7.

Note 2 to entry: Such machines may incorporate facilities for manual control in varying degrees.

Note 3 to entry: Machining centres can accommodate different machining processes, e.g. turning, grinding, etc.

3.2.4
Group 4 machine: Numerical controlled transfer and special purpose machine
numerically controlled machine capable to process only pre-specified workpieces or family of workpieces by means of a pre-determined sequence of machining operations

Note 1 to entry: For illustration, see Annex C, Figures C.8 to C.13 and Figures D.7 to D.8.

3.3 Parts of machines

3.3.1
station
<transfer machine> zone which is processing in each operation of the transfer machine working cycle also including the fixtures, units, spindle heads and other mechanisms associated with the process performed at a particular station

Note 1 to entry: See Figures C.11, C.12 and C.13.

Note 2 to entry: Stations are normally identified by sequential numbering, e.g.:

station 1: Load station

station 2: Machining station

station 3: Gauging station

station 4: Idle station

station xx: Unload station

3.3.2
electronic handwheel
manual pulse generator
MPG
manually operated control device which initiates and maintains an axis movement by pulse generation input to the *numerical control* (3.1.5) during its rotation

3.3.3
workpiece setting station
machine area in which the workpiece is loaded/unloaded

3.3.4
workpiece transfer device
unit typically found on Group 3 and Group 4 machines, which swaps the workpiece located in the work zone with a second workpiece

Note 1 to entry: A typical workpiece transfer device is a pallet changer.

3.3.5
workpiece load/unload mechanism
mechanism that delivers workpieces to, or removes them from, the machine

3.3.6
feed axis
axis for feeding a cutting tool or a workpiece

Note 1 to entry: "Feed axis" may be driven by one or more feed drives.

3.3.7
work zone
zone where the cutting process is taking place

3.3.8
accessible hazard zone
hazard zone of a machine where a stationary standing position with access for the whole body is required with its intended use (e.g. accessible work zone)

3.3.9
spindle
drive system for rotating a cutting tool (tool spindle)

3.3.10
workholding spindle
drive system for rotating a workpiece

3.3.11
counter spindle
spindle which is constructed of two workholding spindles facing each other and those spindles can be rotated synchronously

Note 1 to entry: The counter spindle is a component within the machine which is arranged opposite the main spindle. It allows two-sided machining of a workpiece in which the workpiece is transferred from the main spindle to the counter spindle. The counter spindle moves on the same guideways as the main spindle.

3.4 Mode of operations

3.4.1
mode of operation
MO
provides a defined amount of machine functions under predefined protective measures

Note 1 to entry: Mode of operation is not a function itself. The functions summarized under the term mode of operation can only be used when that particular mode of operation has been activated.

Note 2 to entry: See Clause 5 for safety requirements and measures relating to modes of operation.

3.4.2
mode of operation selection system
MO selection system
facility for manual selection of the machine mode of operation, to which only an authorized group of persons have access

3.4.2.1
mode of operation access device
MO access device
facility which limits access to an authorized group of persons and prevents accidental or abusive actuation of the selection system

3.4.2.2
mode of operation selection device
MO selection device
facility which allows changing the mode of operation of a machine

Note 1 to entry: The selection device can be integrated into the MO access device, e.g. in a key switch (mode of operation selector switch).

3.4.2.3
mode of operation activation device
MO activation device
device that activates a selected mode of operation

3.4.3
mode of operation 0
MO 0
operation of the machine by the operator with non-automatic multi-axis operation, where the operator has control over the machining process without the use of pre-programmed multiple axes operations

Note 1 to entry: MO 0 can also be referred to as manual mode.

Note 2 to entry: The motion of axes can be controlled by direction control or other means.

3.4.4
mode of operation 1
MO 1
automatic, programmed, sequential operation mode of the machine with the facility for manual or automatic loading/unloading of workpieces and tools, until stopped by program or operator

Note 1 to entry: MO 1 can also be referred to as automatic mode.

Note 2 to entry: The automatic mode can include an operational interruption for loading/unloading of workpieces and tools.

3.4.5
mode of operation 2
MO 2
operation mode in which adjustments and preparations for the following machining process are performed by the operator(setter) with the possibility that guards are open and/or protective devices suspended

Note 1 to entry: MO 2 is also be referred to as setting mode.

Note 2 to entry: Assessments of tool or workpiece position (e.g. by touching the workpiece with a probe or tool in single step mode) are procedures of the setting mode (see 5.2.4.5).

3.4.6
mode of operation 3
MO 3
limited automatic mode (fixed sequence of separate consecutive steps) started by the operator, which allows manual control or numerically controlled operation of the machine, with guards opened and/or protective devices suspended

Note 1 to entry: MO 3 can also be referred to as optional mode for manual intervention under restricted operating conditions.

3.4.7
service mode
MO service
operation mode for service and maintenance tasks while guards are open and/or protective devices suspended

Note 1 to entry: Examples for service and maintenance tasks are checking the accuracy of positioning of an axis by laser systems, circular interpolation testing, spindle error analysis, vibration analysis, etc.

3.5 Maximum permissible spindle speed and feed rate

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

3.5.2
safely limited speed
SLS
function to prevent the motor from exceeding the specified speed limit

Note 1 to entry: The SLS function prevents the motor from exceeding the specified speed limit, see IEC 61800-5-2 and also safety functions in Table J.17 (17.3, 17.4).

4 List of significant hazards

4.1 General

This clause contains all the significant hazards, hazardous situations and events identified by risk assessment as significant for this type of machinery and which require action to eliminate or reduce risk.

4.2 Main hazard zones

The main hazard zones are the following:

a) work zones with moving spindle(s) and workpiece(s), clamping components for workpiece and tool clamping, copying unit(s), setting places for workpiece(s) and tool(s), coolant under high pressure, special measuring devices (e.g. laser);

b) handling devices for workpiece loading/unloading;

c) tool magazines and tool changers;

d) area surrounding the swarf and chip conveyor (if integrated);

e) exposed gear box;

f) exposed cam mechanisms;

g) lead screw;

h) feed screw;

i) ball screw;

j) linear and rotary drives.

4.3 Significant hazards and hazardous situations covered by this document

The significant hazards covered by this document are listed in Table 1.

Table 1 — List of significant hazards and hazardous situations

No.	Causes of hazards and hazardous situations	Examples of operations, hazardous situations and hazardous areas	Possible consequences	Relevant subclause in this document
1	**Mechanical hazards**			
1.1	Approach of a moving element to a fixed part	Manual operations between the area of tool and parts of the machine, for milling application, especially the workpiece support or between tool and workpiece Manual operations between the areas of changing mechanisms, e.g. tool changer / workpiece changer or pallet changer	Crushing hazard Shearing hazard Drawing-in or trapping hazard	5.1 5.2
		Feed motion of tool to the work-piece	Crushing hazard Shearing hazard Ejected parts	5.1 5.2
		Manual operations near to the workpiece or machine spindle	Entanglement hazard	
		Clamping of tools and workpieces	Crushing hazard Shearing hazard	5.2.5
1.2	Moving elements	Operations in the near area of moving axes and in the area of automatic loading/ unloading devices during processing, setting, maintenance, repair Operations on tool changer/ workpiece changer/ pallet changer Operations in the area of operating platforms	Impact hazard Drawing-in or trapping hazard Crushing hazard Shearing hazard	5.1 5.2
1.3	Rotating elements	Unintended contact with the rotating tool or rotating workpiece or tool cleaning device	Drawing-in or trapping hazard Friction or abrasion hazard	5.1 5.2
1.4	Cutting parts, sharp edges	Unintended contact with sharp edges of machine elements, workpiece or tool	Stabbing or puncture hazard Friction or abrasion hazard	5.1 5.2

Table 1 *(continued)*

No.	Causes of hazards and hazardous situations	Examples of operations, hazardous situations and hazardous areas	Possible consequences	Relevant subclause in this document
1.5	Falling or ejected objects	Ejection or fall of work material and chips during machining, machine setting, tool changing, maintenance, or shut down — falling workpiece; — tool break; — ejected broken machine element(s) at or near machine	Crushing hazard Impact hazard Stabbing or puncture hazard	5.1 5.2 5.8 5.11 Annex A, Annex B
1.6	Gravity	Falling of moving machine elements during machine setting, e.g. during tool changing or workpiece changing and weight loaded axes Breakage during operation Dropping or falling of machine elements during transport or setup, e.g. activities in the vicinity of gravity-loaded axes Operations in the area of operating platforms or pits	Crushing hazard Shearing hazard Impact hazard	5.2.5.5 5.2.5.6 Annex G
1.7	Height in relation to the floor	Fall from high situated work places	Impact hazard Slip, trip, and fall hazards	5.14
1.8	High pressure	At hydraulic elements during stay at or near machine, especially during installation of the machine Start-up and working on coolant systems	Penetration or impact of media under pressure into the skin/eyes	5.8.1 b) 5.8.1 c)
1.9	Lack of stability	Unrestrained machine or machine part falls or overturns during stay at or near machine	Impact hazard Crushing hazard Shearing hazard	5.12
1.10	Rough, slippery surface	Operations on ground and in the area of stairs around the machine, as well as work at height due to: — ejection or spillage of metal cutting fluid, lubricants or hydraulic fluid; — residuals, contained in ejected fluids; — insufficient railing or other restraining facilities, especially at places where a fall hazard exists	Slip, trip, and fall hazards	5.13 5.14
2	**Electrical hazards**			
2.1	Live parts	Contact with live parts	Electric shock hazard	5.3
2.2	Parts which have become live under fault	Contact with parts which are live by fault	Electric shock hazard	5.3

Table 1 *(continued)*

No.	Causes of hazards and hazardous situations	Examples of operations, hazardous situations and hazardous areas	Possible consequences	Relevant subclause in this document
3	**Thermal hazards**			
3.1	Objects or materials with high/low temperature	Ejection of hot swarf or workpieces during milling operation during stay at and/or near machine, and hot/cold surfaces	Burn hazard Frostbite hazard	5.6
3.2	Explosion		Burn, fall, and bump hazards	5.6 Annex E Annex F
3.3	Flame		Burn hazard	5.6 Annex E Annex F
4	**Noise hazards**			
4.1	Manufacturing process and moving elements	Vibration of tool and/or work material while processing, drive and transmission elements, during stay at or near machine blowing air for cleaning	Permanent hearing loss All further (e.g. mechanical, electrical) problems due to Interference with speech communication or acoustical signals	5.4
5	**Vibration hazards**			
5.1	Vibrating elements	Transfer of vibrations from the milling process to the operator	Discomfort Neurological disorder	5.7
6	**Radiation hazards**			
6.1	Low- and high-frequency electromagnetic radiation	At electrical equipment, especially during setup or maintenance	Burn hazard	5.5
6.2	Optical radiation (infrared, visible and ultraviolet), including laser	At measuring equipment especially during setup or maintenance	Eye and skin injuries	5.5
7	**Material/Substance hazard**			
7.1	Biological or microbiological substance (viral or bacterial)	Contact with contaminated coolant during stay at and/or near machine	Infection hazard	5.6
7.2	Fluid	Skin contact with coolant, during stay at and/or near machine	Skin damage	5.6
7.3	Mists and vapour	Inhalation and ingestion of substances used or generated during operation (e.g. coolant) during stay at and/or near machine	Difficulties of breathing, poisoning	5.6
7.4	Combustible dust	Operating with: — combustible dust, e.g. aluminium-, titan-, magnesium swarf, and/ or — flammable coolant, e.g. oily coolant	Fire Explosion hazard, burns	5.6 Annex E Annex F

Table 1 *(continued)*

No.	Causes of hazards and hazardous situations	Examples of operations, hazardous situations and hazardous areas	Possible consequences	Relevant subclause in this document
8	**Ergonomic hazards**			
8.1	Design or location of visual display units	Misinterpretation of displayed information at work place of operator	All further (e.g. mechanical, electrical) problems due to human errors	5.7
8.2	Design, location or identification of control devices	Maloperation of the machine at work place of operator		5.7
8.3	Excessive effort	At control devices and during handling Inadequate consideration of anatomy of hand/arm or foot/leg during workpiece or tool changing Inadequate consideration of body posture during maintenance tasks	Fatigue	5.7
8.4	Body posture		Musculoskeletal disorders	5.7
8.5	Repetitive activities		Fatigue, Motivation for defeating of safeguarding equipment	5.7
8.6	Visibility, local lighting	Operations during handling/positioning of work material and the tool, during loading/unloading, during machine setting, tool changing and maintenance	Judgement and accuracy of manual actions impaired Fatigue Human errors	5.7
8.7	Human error/human behaviour	Reasonably foreseeable misuse of the machine Incorrect work material and milling tool handling and setting Insufficient design of work place and/or organization of the machining process Inadequate consideration of anatomy of hand/arm or foot/leg Faulty mounting	All above listed hazards	5.10
9	**Hazards related to the operational environment of the machine**			
9.1	Electromagnetic interference	Uncontrolled movements (including changes in speed, unintentional, unexpected start-up)	Crushing, shearing, trapping, entanglement hazards	5.8.8

Table 1 *(continued)*

No.	Causes of hazards and hazardous situations	Examples of operations, hazardous situations and hazardous areas	Possible consequences	Relevant subclause in this document
10	**Combination of hazards**			
10.1	Failure of the power supply	Fall or ejection of moving machine elements or clamped workpiece or tool Failure of stopping moving elements	Crushing hazard Shearing hazard Impact hazard Cutting or severing hazard Entanglement hazard Drawing-in or Trapping hazard Stabbing or puncture hazard Friction and abrasion hazard	5.8 5.9
10.2	Restoration of energy supply after an interruption	Uncontrolled movements (including change of velocity) unintended/unexpected start-up		5.8 5.9
10.3	Failure/disorder of the control system	Fall or ejection of moving machine elements or clamped workpiece or tool Failure of stopping moving elements Uncontrolled movements (including change of velocity) Unintended/unexpected start-up Other hazardous situations due to failure or inadequate design of the control system		5.8 5.9

5 Safety requirements and/or protective/risk reduction measures

5.1 General requirements

5.1.1 General

In addition to the requirements of this clause, machinery shall be designed according to the principles of ISO 12100 for relevant but not significant hazards, which are not dealt with in this document.

The selected cutting speed of the machine shall not exceed the maximum permissible cutting speed of the tool in use.

Applicable safety functions for hazardous movements in work zone shall fulfil requirements listed in Table J.18.

Applicable safety functions for hazardous movements in the maintenance area shall fulfil requirements listed in Table J.19.

Applicable safety functions for interface to load/unload applications shall fulfil requirements listed in Table J.20.

5.1.2 Guards requirements

5.1.2.1 General

Guards shall be in accordance with ISO 14120.

5.1.2.2 Fixed guards

The requirements are the following.

a) Where fixed guards are floor-mounted (e.g. perimeter fencing), they shall have at least a height of 1 400 mm and a distance in accordance with ISO 13857:2019, Table 2, to prevent access to the hazard zone. Any opening between the bottom of the guard and the floor shall not exceed 200 mm according to ISO 11161:2007, 8.5.2.

b) Access to mechanical power transmission drives (e.g. chains and sprocket wheels, gears, feed screws, ball screws, etc.) shall be prevented by fixed guards in accordance with ISO 14120:2015, or the structures of the machine act as fixed guards. Openings in the guards and their distance to the hazardous area shall be designed in accordance with ISO 13857:2019.

5.1.2.3 Manually operated moveable interlocked guards

The requirements are the following.

a) Movable interlocked guards shall be interlocked with or without guard locking in accordance with ISO 14119:2013 in order to prevent access to hazardous areas where hazardous machine movements take place. It shall be ensured that the hazard zone cannot be reached when opening an interlocking guard before the hazardous machine motion has stopped in accordance with ISO 13855:2010, Clause 9. The selection of interlocking devices shall be in accordance with ISO 14119:2013, Clause 6. Safety function for the release of the guard locking shall fulfil the requirements in Table J.17 (17.2).

b) A detected failure in the interlocking device, i.e. function or arrangement, shall result in a stop of the machine initiated by a safety related stop function according to Annex J. Only for control with integrated safety technology, SOS in accordance with IEC 61800-5-2 satisfies the above-mentioned requirements (SS2). This measure does not apply in all cases, where the stop itself is also afflicted by error (e.g. energy loss).

c) The opening of a guard shall cause the safety requirements of the selected MO to be initiated.

d) If prolonged movement (e.g. coast of spindle) is to be expected after a power failure, access to the machine shall be prevented by guard locking device in de-energized state.

e) Measures to minimize possible defeat of interlocking device(s) shall be taken (see ISO 14119:2013, Clause 7).

f) Interlocking guards with a start function (control function) shall only be used if all requirements of ISO 12100:2010, 6.3.3.2.5, are fulfilled.

5.1.2.4 Power-operated moveable interlocked guards

5.1.2.4.1 General

Closing of the guard can be used as a start command for the machine, if the guard system meets the requirements of ISO 12100:2010, 6.3.3.2.5.

Movements of gravity loaded power-operated guards shall not result in any hazardous situation when power loss takes place, e.g. by non-return valves, blocking or clamping devices or brakes.

Power operated movable guards for user access can be realized as automatic power operated movable guards or manually controlled power operated movable guards.

All applicable safety functions listed in Table J.13 shall be fulfilled.

5.1.2.4.2 Power-operated moveable interlocked guards where motion is maintained automatically by the control system

a) Machines without accessible hazard zone

Power-operated moveable interlocked guards shall be in accordance with ISO 12100:2010, 6.3.3.2.6 and ISO 14120:2015, 5.2.5.4 and shall be equipped with a protective device to avoid shearing hazards at the front edge or shall be provided with round edges with a radius of at least 2 mm for each edge and a combined radius value (sum of the two radii) of at least 6 mm. If one side is a flat surface, this side shall have a width of more than 30 mm and the other side shall have a minimum radius of 6 mm.

— If pressure-sensitive edges are provided, they shall be fitted on the total length of the front edge up to a maximum height of 2 700 mm above the floor or platform (ISO 13857:2019, 4.2.1.2). The pressure-sensitive edge shall be in accordance with ISO 13856-2. While opening there shall be no hazards posed by crushing and shearing edges.

— If reduced forces are used, 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.

Limitation of energy and forces shall be done according to ISO 14120 and length of time period according to EN 16005.

NOTE 1 The force can be measured e.g. with a device consisting of a piston provided with a scale acting on spring, a smooth sleeve making it possible to measure the extreme point of movement at the moment of impact. A simple calculation can be used to determine the scale that corresponds to the specified limit values (see EN 81-1:1998+A3:2009, 7.5.2.1.1.2).

b) Machines with accessible hazard zone

In addition to 5.1.2.4.2 a), further additional measures according to 5.2.3.2 b) shall be provided to prevent entrapment in the hazard zone and a start command for closing of the power operated moveable guard shall only be possible from outside the accessible hazard zone.

NOTE 2 The requirements of 5.1.2.4.2 are also applicable where motions of power-operated movable interlocked guards are initiated by a push button, softkey, M-Function, touch screen, etc.

5.1.2.4.3 Manually controlled power-operated moveable interlocked guards

For manually controlled power-operated movable guards, one of the following protective measures shall be provided:

a) manual operation of the power-operated guard by means of two-hand control (ISO 13851). The control panel of the operator shall be fixed in case of movement of the power-operated guard and the actuating mechanisms of the two-hand control shall be located at a sufficient distance to the hazard area according to ISO 13855:2010, Clause 8: at least 100 mm with adequate shrouding with the two buttons B1 (first hand) and B2 (second hand) of a two-hand control;

b) manual operation of the power-operated guard by means of enabling device (see ISO 12100) and direction control:

— a minimum distance to the hazard area is not mandatory for the operator;

— enabling device and direction control are mounted on a control panel or on a portable manual control panel to ensure full visibility to the hazard area for the operator;

— as long as there is only an impact hazard (gap >300 mm), travel speed up to 25 m/min is allowed;

— when the gap between the movable power-operated guard and the fixed guard is less than 300 mm presenting a shearing or crushing hazard, a maximum travel speed of only 5 m/min is allowed;

— by releasing the enabling device (first hand) or the direction control device (second hand), the drive shall decelerate to a standstill initiated by a safety related stop function for the enabling device, depending on the mode of operation; or

c) manual operation of the power-operated guard by means of a hold-to-run device. The location of the hold-to-run control device shall be at least 2,10 m from the edge of the guard or safeguarding measures as described in 5.1.2.4.2 a) shall be in place. By releasing the hold-to-run device, the drive shall decelerate to a standstill initiated by a safety related stop function.

5.1.3 Requirement for gravity loaded axes

Means shall be provided to prevent hazardous movement of vertical or slant axes under gravity, e.g. redundant restrain system, brakes, counter balance as given in Annex G. For requirements concerning safety functions, e.g. control function, to prevent unintended descent of vertical or slant axes (see Table J.3)

5.2 Specific requirements resulting from mechanical hazards

5.2.1 Protective measures for Group 1 machines

The following requirements for safeguarding of Group 1 machines shall be fulfilled.

a) To inhibit access to the cutting tool (see Figure D.1) adjustable guard(s) shall be provided. Guards shall be in accordance with ISO 14120, interlocking shall be in accordance to ISO 14119:2013.

b) 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.

c) Protective clothing and training are important. As the operator is not completely protected from ejection hazards in the work zone, special attention shall be given to the documentation, i.e. the instructions for use, to ensure that the operator has the required qualification and uses the personal protective equipment (PPE), e.g. safety glasses, tight fitted clothing, etc. [see instructions in 6.3.1 q)].

d) Continuous powered axis feed rate shall not exceed 2 m/min and/or a hold-to-run controlled rapid traverse axis speed not exceeding 5 m/min.

If Group 1 machines provide continuous powered axis feed speed exceeding 2 m/min and/or hold-to-run controlled rapid traverse axis speed exceeding 5 m/min, then the requirements of 5.2.2 for Group 2 shall also apply to Group 1 machines.

5.2.2 Protective measures for Group 2 machines

The characteristics of guards and specific requirements for Group 2 machines are the following.

a) The work zone shall be guarded with fixed and/or interlocked movable guard(s) (see Figure D.2). Guards shall be in accordance with ISO 14120, interlocking shall be in accordance with ISO 14119:2013. Guard locking (see ISO 14119) shall be provided when opening of the interlocked movable guard provides access to any hazards during deceleration (i.e. run-down) (see ISO 13855:2010, Clause 9).

b) Any machine movements (except in case of 5.2.2. c) shall only be possible when the interlocked movable guard(s) are/is closed. Opening of an interlocked movable guard shall cause the hazardous movements to stop and to be inhibited. The stop shall be in category 0 or category 1 according to

IEC 60204-1:2016, 9.2.3.3. For control with integrated safety technology, SOS, SS2, SS1, and STO in accordance with IEC 61800-5-2 satisfy the above-mentioned requirements.

c) When powered machine movements are required with the movable guard open (e.g. for setting), these movements shall only be permitted under the following restrictions:

   1) axis feed moving speed shall be limited to 2 m/min and initiated and maintained with a hold-to-run control device (ISO 12100:2010, 3.28.3);

   2) spindle rotation shall be initiated and maintained by one of the following means:

      — a hold-to-run control device;

      — a spindle start device together with an enabling device. When a manual data input (MDI) followed by command “cycle start” is carried out, the axis and spindle movement shall be initiated and maintained only while the enabling device is actuated. Releasing the enabling device shall initiate a safety related stop function according to Annex J. For control with integrated safety technology, SOS, SS1, SS2, and STO in accordance with IEC 61800-5-2 satisfy this requirement;

   3) the rotational speed of the spindle shall be limited by the capability to stop the rotation, while the moveable guard is open, and the safety functions are effective. After a stop command, the spindle shall stand still within 2 revolutions without tool. In case of power loss or errors in the control or the power elements, coast of spindle drive is permissible.

d) To prevent access to moving machine elements, fixed and/or interlocked movable guard(s) shall be provided when

   — impact hazards exist and the linear speed exceeds 15 m/min; or

   — crushing, shearing or trapping hazards exist and linear speed exceeds 2 m/min.

   The safety distances for guards to prevent the operator or other exposed persons from reaching into the hazard zone shall be according to ISO 13857:2019, Tables 4 to 7.

5.2.3 Protective measures for Group 3 and Group 4 machines

5.2.3.1 Access to the work zone

Safeguards shall be provided to reduce the risks listed in Table 1 (e.g. entanglement, crushing, shearing, etc.) by preventing access to dangerous parts/areas of the machines (see Clause 4). General guidance for the selection of safeguards, where the hazards from moving parts cannot be avoided by design, is given in 5.1.2 and in ISO 12100:2010, 6.3. For features of guards used to minimize the hazards of ejection, see 5.11.

The work zone shall be enclosed where reasonably practicable by fixed and/or interlocked movable guards during machining operations.

When using ESPE or PSPD, protective equipment for detecting access to the work zone shall be in accordance with the following standards:

— for ESPE: IEC 61496-1, IEC 61496-2, IEC 61496-3;

— for PSPD: ISO 13856-1:2013, ISO 13856-2:2013, ISO 13856-3.

NOTE See 3.1.8 for ESPE and 3.1.10 for PSPD.

Distances between the protective device (e.g. AOPDs) and the work zone shall be in accordance with ISO 13855 regarding the approaching speed.

5.2.3.2 Characteristic of guards

The characteristics of guards and specific requirements for Group 3 and Group 4 machines are the following.

a) Where routine observation of the machine operation is required (i.e. more than once per shift), means (e.g. windows) shall be provided so that this can be achieved without the need to open, remove or suspend any work zone guarding or other protective device(s) (see also Table 1, 8.6 on visibility and local lighting).

b) Interlocking of guards: When persons can have whole body access or can remain in the hazardous zone(s) without being visible to the operator, means to inhibit restart shall be provided. These means can be:

   — presence-sensing protective equipment;

   — door closure inhibition by technical means (e.g. secured by interlock blocking device like padlocks);

   — double acknowledgement (inside and outside the protective device);

     NOTE One method of accomplishing a special reset solution is to use a second reset actuator. In this case, the reset function will be initiated within the danger zone by the first actuator in combination with a second reset actuator located outside the danger zone (near the safeguard). This reset procedure is realized within a limited time before the safety-related parts of the control system accept a separate restart command (see ISO 11161:2007, 8.9).

   — acknowledgement from a position that allows viewing the hazardous area (direct activation of the guard locking device);

   — unintended closing of the guards and trapping of persons shall be prevented e.g. by gravity, spring operated or hole for padlock.

c) When interlocking devices with guard locking are used locking shall be power-on released (ISO 14119:2013, 4.3.3, Figure 5 a) c)). If there is an accessible hazard zone an escape release (ISO 14119:2013, 5.7.5.2) in combination with manual reset of the interlocking device shall be provided if power-on released according to ISO 14119:2013, 4.3.3, Figure 5 a) is used.

d) Alternatives to enclosures: Where enclosure is not reasonably practicable (e.g. due to the size of the workpiece, its geometry, other special characteristics of the machine or its application), operators and other exposed persons shall be safeguarded by a combination of other means (e.g. protected operator position by a cabin, perimeter fence, other protective devices). For example, where external equipment (e.g. crane) is used to load/unload workpiece to a large size machine, cabin and perimeter fence are more practical safeguards than an enclosure. See 5.15 for more information on operator cabins and perimeter fencing.

5.2.4 Mode of operation (MO)

5.2.4.1 General requirements

Table 2 assigns the various, in this document standardised, modes of operation (MO) to the machine groups defined in this document (Group 1 to Group 4 machines). Standardized modes of operation may be:

— inherent: the MO is, due to technical limitations or lack of automatic control capability, the only possible mode of operation;

— mandatory: the MO shall be provided;

— optional: the MO may be provided; or

— not allowed: the MO shall not be provided to operate a machine belonging to a particular group.

Table 2 — Overview of machine groups and modes of operation

Mode of operation (MO)	**Group 1** Manually controlled boring and milling machines without numerical control	**Group 2** Manually controlled boring and milling machines with limited numerical controlled capability	**Group 3** Numerically controlled boring-, milling machines and machining centres	**Group 4** Numerically controlled transfer and special purpose machines
MO 0 Manual	Inherent	Mandatory	N/A [b]	N/A [b]
MO 1 Automatic	N/A	Mandatory see 5.2.2	Mandatory	Mandatory
MO 2 Setting [a]	N/A	Optional	Mandatory	Mandatory
MO 3 Manual intervention under restricted operating conditions	N/A	N/A	Optional	Optional
MO Service[a] Service mode	N/A	Optional	Optional	Optional

[a] In order to allocate access authorization, it may be necessary to provide different key switches (or other appropriate access means) for one machine.

NOTE 1 Example of implementation:

Key 1: Access to setting mode (and automatic mode) for setting staff [see 6.3.1 a) 3)];

Key 2: Access to NC program code and user related NC-parameter modifications for adequately trained staff [see 6.3.1 a) 3)].

Key 3: Access to mode of operation 3 for adequately trained an authorized staff [see 6.3.1 a) 3)].

Key 4: Access to service mode for trained service staff of the machine user [see 6.3.1 a) 3)].

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

[b] Manual machining without NC capability is possible in MO 1, see 5.2.4.4.

If a machine provides more than one mode of operation, the machine shall be equipped with a MO selection system.

The selected MO shall be displayed on the machine according to 6.2.2.

5.2.4.2 Requirements for MO selection system (Group 2, Group 3 and Group 4 machines only)

The selection of a MO shall be done according to Figure 1.

The MO selection system consists of a security system (named Security in Figure 1) and a safety system [named Safety (SRP/CS) in Figure 1]. The sole purpose of the security system is the prevention of unauthorized access to the safety system, which contains the actual MO selection device and the MO activation device. The security system itself is not a safety related part of the control system (SRP/CS).

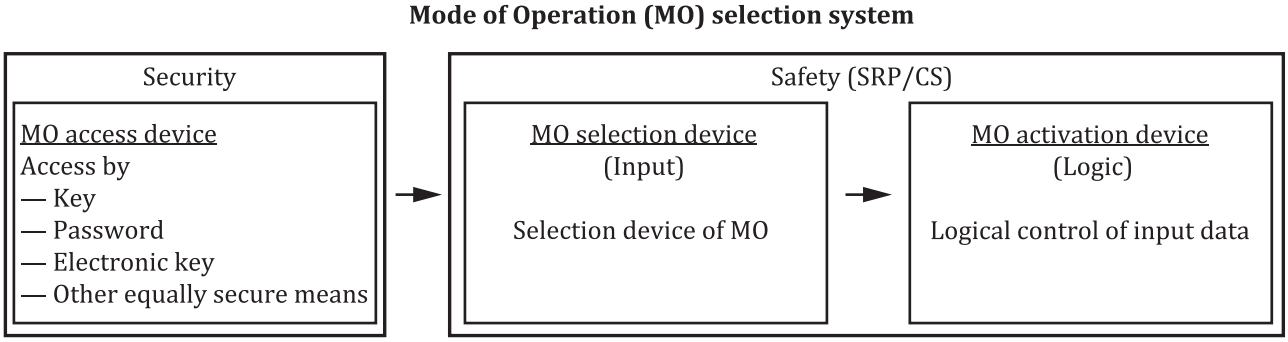


Figure 1 — Border between security system and safety system

The MO selection device (safety) and the associated control system arrangements (SRP/CS) shall ensure that only one MO is selected and enabled at any time.

All applicable safety functions listed in Table J.15 shall be fulfilled.

The selection of a MO shall only be permitted from outside the hazardous areas.

The safety relevant part of the MO selection system shall be capable of being locked. Mode selection by itself shall not initiate machine operation. The following requirements shall be fulfilled for the selection of MO.

a) If more than one location (control console) is available for MO selection at a hazard zone of several machines or interacting partial machines and a different mode of operation than MO 1 is selected from an arbitrary control console of a dedicated hazard zone, the automatic cycle shall be interrupted for this particular hazard zone before access to this hazard zone is enabled.

b) Every selected MO shall be indicated visually [e.g. by visual display on the control panel, by coloured signal lamps or a text on the user interface (HMI – human machine interface)]. See also 6.2.2, Table 6. In special cases, if necessary, audible signals can also be used (see ISO 11161:2007, 8.10).

c) Dynamic mode selection is not permitted when the machine is running. A dynamic transition between MO 1 and MO 3 is applicable to Group 3 and Group 4 machines only (see 5.2.4.6).

5.2.4.3 Mode of operation 0: Manual (MO 0)

When MO 0 is selected, the following requirements apply.

a) If interlocked moveable guards are provided, the spindle rotation shall only be initiated manually by a control device provided for that purpose when these guards are closed. Movement of spindle with these guards open shall only be initiated and maintained with the enabling device actuated. Releasing the enabling device shall initiate a safety related stop function of the spindle rotation.

b) Axis feed movements shall be possible with interlocked moveable guards closed, and traverse movement speed shall be limited to 5 m/min. Axis feed movement with open interlocked moveable table guards shall be manually selectable and shall only be possible by hold-to-run control with 2 m/min limited speed.

c) Rapid traverse movements shall be manually selectable and shall only be possible by hold-to-run control.

d) With controllable power-driven feed axes, only one feed axis movement is allowed at a time. The spindle is permitted to rotate at the same time. Releasing the enabling device stops the spindle and feed motion initiated by a safety related stop function.

e) Applicable safety functions listed in Table J.17 (17.7, 17.8) shall be fulfilled.

5.2.4.4 Mode of operation 1: Automatic (MO 1)

MO 1 is the standard mode for production and can use the full performance of the machine. Manual movement of the machine axes and machining with running spindle drive is permitted with all safeguards active and guards closed. When MO 1 (automatic mode) is selected, the following conditions apply before the machine is started.

a) Moveable interlocked guards which give access to the work zone shall be closed and the protective devices shall be active to permit and maintain operation in automatic mode.

b) If whole body access to the hazardous area is possible, it shall be ensured that no persons are present in that area. If it cannot be ensured that persons can be seen from the position where the control devices for start/restart are located, requirements from 5.2.3.2 b) shall be fulfilled.

c) Where multiple main control cycle start devices are provided and the operators can therefore put each other in danger, only one shall be enabled at any time [see ISO 12100:2010, 6.2.11.8 e)]. If it is possible to start the same hazardous element by means of several controls, the control circuit shall be arranged that only one control is effective at any given time.

d) For start/restart in MO 1, the following requirements shall be fulfilled:

   — the start/restart shall only be initiated from a control station where no hazard exists;

   — protective devices relevant for this mode of operation including their safety related functions shall be properly arranged and active;

   — the control device(s) for start/restart shall be located to allow a clear and unobstructed view to persons within the hazardous area.

   Movements only associated with loading/unloading of tools/workpieces in MO 1 with guards open shall be possible with specific requirements stated in 5.2.5.1 (machine with tool magazine), 5.2.5.2 (machine with tool changer), 5.2.5.3 (machine with workpiece handling mechanism), 5.2.5.4 (machine with workpiece setting station) and 5.2.5.5 (machine with workpiece clamping mechanism).

5.2.4.5 Mode of operation 2: Setting (MO 2)

5.2.4.5.1 Basic specifications

MO 2 is a mode of operation which allows the operator to perform adjustments for the following machining process with movable interlocked guards open and/or protective devices suspended. Assessment of the tool and workpiece position, e.g. by touching the workpiece with a probe or tool, is part of the setting mode.

When changing to MO 2 from any other MO, the working cycle shall firstly be interrupted and then access to the work zone can be enabled (e.g. by unlocking the interlocked guard with guard locking).

When a hold-to-run control device or electronic handwheel is used, single movement and spindle rotation shall be initiated and maintained only while the enabling device is actuated. Releasing the enabling device shall initiate a safety related stop function according Annex J. An enabling device is not required if the hold-to-run control device or electronic handwheel complies with the safety requirements according to 5.8.6.

When a manual data input (MDI) followed by command 'cycle start' is carried out, single axis and spindle movement shall be initiated and maintained only while the enabling device is actuated.

5.2.4.5.2 Range of functions

When any interlocked movable guard is open, and/or a protective device is suspended, hazardous powered machine movements shall only be permitted under the following conditions:

a) singular linear feed movements:

   — shall be limited to a maximum of 2 m/min (for safety function, see Table J.2 (2.4), Table J.4 (4.10), Table J.18 (18.5)); or

   — the movement shall be in steps with a maximum increment of 10 mm;

b) for rotary axes (including workpiece and workholding spindle):

   — peripheral speeds shall be limited to 15 m/min (for safety function, see Table J.2 (2.4), Table J.4 (4.10), Table J.18 (18.5); and

   — rotation speed shall be limited to 50 min^{-1} (see ISO 23125:2015, 5.2.4.4.1 d);

c) spindle speed shall be limited by its braking ability. After a stop command the spindle shall stand still within two revolutions without tool;

   NOTE The number of two revolutions only refers to the displacement/angle covered by the deceleration procedure. Response time of the operator is not included, e.g. releasing the enabling device and control are not included.

d) the limits of rotational speed or axis feed movements or incremental distance [defined in a), b) and c) above] shall be monitored (see 5.8.7 and speed limit control in Table J.17 (17.3, 17.4). A stop shall be initiated when the speed limit is exceeded. The stop function of the movement shall be initiated by a safety related stop function according to Annex J;

e) unguarded swarf/chip conveyor movements shall only be initiated and maintained by a hold-to-run control device or an enabling device (first hand) in conjunction with a direction control (second hand) (see J.11.2 to J.11.3) but not in conjunction with feed axes and spindle movement;

f) for group 3 and group 4 machines only: Automatic tool- and workpiece changing mechanisms shall remain inhibited in case of pending operations within the work zone. Initiation of their automatic movement shall only be possible by reselection of MO 1. Manually controlled single movements of tool- and workpiece changing mechanisms are permitted in conjunction with an enabling device. Every movement shall be initiated by a start command. This can be achieved, for example, by MDI;

g) releasing the enabling device or the hold-to-run control device (see 5.8.6. a) shall initiate a safety related function according Annex J (marked as SF07-1 and SF07-2);

h) high pressure coolant shall be inhibited (see Table J.12).

5.2.4.6 Mode of operation 3: Manual intervention under restricted operating conditions (MO 3)

5.2.4.6.1 Basic specifications

MO 3 is an optional mode of operation, which permits the operation of the machine under manual or numerical control while guards are open and/or protective devices suspended.

This mode of operation is only permitted to group 3 and group 4 machines.

MO 3 may only be provided if the work task requires the opening of guard(s) and/or suspension of other protective devices.

Typical work tasks and applications for MO 3 with enabling device are the following:

— cleaning of workpiece, e.g. removal of chips to prevent surface scratching;

— CNC/NC program tests, especially cycle test with higher speeds of axes and/or spindles than permitted in MO 2 and direct observation with guard open is necessary;

— use of contact-type centring tools on hidden parts that cannot be seen from the front or on the back side of the workpiece, such as "edge finder"(observation of contact point by manual pulse handle feed in the rotated state).

NOTE The limited range of functions (see 5.2.4.6.2) provided in MO 3 give a motivation to switch back to the higher performance of MO 1.

When selecting the modes of operation MO 1 or MO 3, the following sequences shall be implemented.

— The change from MO 1 to MO 3: First the operating conditions of MO 1 shall be reduced to those demanded in MO 3 and shall be monitored. Then the relevant safety requirements (e.g. the possibility for opening of guards or the interruption of protective devices) shall be allowed.

— The change from MO 3 to MO 1: First the higher safety requirements of MO 1 (e.g. movable guards closed, or light curtain activated) shall be activated, then the higher values of the operating conditions of MO 1 shall be allowed.

5.2.4.6.2 Range of functions

When any interlocked movable guard is open, and/or a protective device is suspended, hazardous powered machine movements shall only be permitted under the following conditions:

a) Singular linear axis feed movements shall be:

   — limited to 5 m/min; or

   — in steps with a maximum increment of 10 mm.

b) For rotary axes (including workpiece and workholding spindle):

   — peripheral speeds shall be limited to 15 m/min; and

   — rotation speed shall be limited to 50 min^{-1} [see ISO 23125:2015, 5.2.4.4.1 d)].

c) Spindle speed shall be limited by its braking ability. After a stop command the spindle shall stand still within five revolutions without tool.

   NOTE The number of five revolutions only refers to the displacement/angle covered by the deceleration procedure. Response time of the operator is not included, e.g. releasing the enabling device and control are not included.

d) The limits of rotational speed or axis feed movements or incremental distance [as defined in a), b) and c)] shall be monitored [see 5.8.7 and speed limit control in Table J.17 (17.3, 17.4)].

e) Non-programmed movements shall be achieved as follows.

   1) Spindle rotation shall be initiated by a spindle start control device together with an enabling device and maintained by the enabling device.

   2) Axis movements shall be initiated and maintained by one of the following means:

      — a hold-to-run device;

      — an electronic handwheel; or

      — manual data input (MDI) followed by cycle start together with an enabling device.

f) Execution of a program shall be initiated by a cycle start control device in conjunction with an enabling device and maintained by the enabling device.

g) Unguarded swarf/chip conveyor movements shall only be initiated and maintained by a hold-to-run control device or an enabling device (first hand) in conjunction with a direction control (second hand) (see J.11.2 to J.11.3) but not in conjunction with feed axes and spindle movement.

h) Automatic tool and workpiece changing mechanisms shall remain inhibited in case of pending operations within the work zone. Initiation of their automatic movement shall only be possible by reselection of MO 1. Manually controlled single movements of tool and workpiece changing mechanisms are permitted in conjunction with an enabling device. Every movement shall be initiated by a start command. This can be achieved, for example, by MDI.

i) Releasing the enabling device or the hold-to-run control device (see 5.8.6 a) shall initiate a safety related function according Annex J (marked as SF07-1 and SF07-2).

j) high pressure coolant shall be inhibited (see Table J.12).

NOTE In certain machining processes, e.g. with complex workpieces in single-part production, it can be necessary for the operator to observe the machining process when the guards are open and/or to take corrective action via the control device. Therefore, it is possible that the use of an enabling device over a longer period of time is not practicable for ergonomic reasons or that the setting of several parameters on the control device prevents the continuous actuation of the enabling device. In this case, an additional mode of operation can be provided using further protective measures. Due to the variety of possible machining processes that can require an additional operating mode, it is not possible within this document to standardise a corresponding operating mode. A technical report on this document with examples for the application of additional operating modes is being prepared.

5.2.4.7 Service mode (MO Service)

This mode of operation is intended for service tasks, such as calibration measurement, troubleshooting, diagnostic and checking of machine functions and performance. Therefore, MO Service enables restricted functionality of the machine or parts of it, at which guards of the individual work zone can be opened.

MO Service shall only be provided to service staff, who is trained by the manufacturer/supplier of the machine.

a) The following restrictions for automatic functionalities are required to provide this mode.

   1) Simultaneous rotation of the spindle and axis motion is allowed only for measurement and calibration tasks.

   2) Feed axis/axes can be moved under to following restrictions:

      — with enabling device (PLr = d, Cat. 3) in conjunction with a hold-to-run control device;

      — with enabling device (PLr = d, Cat. 3) in conjunction with a start command (PLr = b) and actuated override selection device; or

      — if axes speed is lower than 15 m/min and safely limited in PLr = d, Cat. 3 (SLS) in conjunction with a start command (PLr = b) and actuated override selection device, an enabling device is not required.

   3) Spindle rotation shall be initiated and maintained under the following restrictions:

      — with an enabling device (PLr = d, Cat. 3) in conjunction with a hold-to-run control device; or

      — with an enabling device (PLr = d, Cat. 3) in conjunction with a start command (PLr = b) and actuated override selection device.

   4) Spindle speed shall be limited by its braking ability. After releasing the enabling device or the hold-to-run device the spindle shall stand still within five revolutions without tool.

NOTE The number of five revolutions only refers to the displacement/angle covered by the deceleration procedure. Response time of the operator is not included, e.g. releasing the enabling device and control are not included.

5) If movement of tool changer and/or tool magazine is foreseen, automatic tool changing movements or tool magazine movement shall be initiated by a hold-to-run control device. It shall be possible to initiate the individual steps successively.

6) If the pressure of coolant is higher than 0.5 MPa an enabling device (PLr = d, Cat. 3) in conjunction with a permanently actuated hold-to-run control device is required to initiate and maintain the coolant supply.

7) Pneumatic or hydraulic movements of machine parts shall be initiated and maintained with an enabling device (PLr = d, Cat. 3) in conjunction with a permanently actuated hold-to-run device.

8) Tool measuring using laser-based methods are not permitted.

9) Movements of the chip conveyor shall be initiated and maintained with an enabling device (PLr = d, Cat. 3) in conjunction with a permanently actuated hold-to-run device.

b) More than one feed axis can be moved.

c) Movements of automatic workpiece changing mechanisms shall, if applicable, be carried out with reduced speeds. The individual steps shall be initiated in succession.

5.2.5 Optional or additional equipment for machines

5.2.5.1 Additional requirements for tool magazine(s)

If the machine is equipped with tool magazine(s), the following requirements shall be fulfilled.

a) Access to the tool magazine shall be prevented by fixed and/or interlocked movable guards. Where routine observation of the tool magazine is required, means (e.g. windows) shall be provided.

b) When the interlocked movable guards are opened or the protective devices according to 5.2.3.1 suspended, the tool magazine drive(s) shall be stopped, and further movements shall be inhibited.

c) Access openings shall be in accordance with ISO 15534-1:2000 and ISO 15534-2:2000.

d) For any accessible hazard zone of the tool magazine, the same requirements as for the work zone shall be applied. Powered movements of the tool magazine with guards open/protective devices according to 5.2.3.1 suspended are permitted when carried out in accordance with the following:

— an enabling device together with direction control; In this case, movement shall be at a reduced speed of a maximum of 15 m/min where only an impact hazard exists or where a crushing, shearing or trapping hazard exists either be able to stop in less than 4 mm or be a maximum of 2 m/min; or

— a two-hand-control.

The requirements of ISO 13851:2019 type II or type III B shall be fulfilled. However, the minimum button separation of 260 mm in ISO 13851 can be suspended if there is no way to actuate the two hand devices with one hand, for example by two independent knob type switches or rotary type switches.

NOTE Types of switches, rotary type and knob type, are described in EN 894-3+A1:2008.

The distance requirements of ISO 13855:2010, Clause 8, apply (at least 100 mm).

e) No machine movements shall be initiated from the actuation of any sensor or feedback device while the interlocked guards are open (see IEC 60204-1:2016, 10.1.4).

f) Means shall be provided to prevent movements of vertical or slant axes under gravity, e.g. brakes (see Annex G).

g) All applicable safety functions listed in Table J.10 shall be fulfilled.

5.2.5.2 Additional requirements for tool changer(s)

If the machine is equipped with tool changer(s), the following requirements shall be fulfilled.

a) Access to hazardous movements of the tool changer(s) from any direction shall be prevented by fixed and/or interlocked movable guards.

b) When the safeguarding measures are suspended, the tool changer drive(s) and other hazardous movements shall be stopped, and further movements shall be inhibited.

c) Powered movements of the tool changer with guards open/protective devices according to 5.2.3.1 suspended and no whole-body access are permitted when carried out in accordance with the following:

— an enabling device together with direction control; In this case, movement shall be at a reduced speed of a maximum of 15 m/min where only an impact hazard exists or where a crushing, shearing or trapping hazard exists either be able to stop in less than 4 mm or be a maximum of 2 m/min; or

— a two-hand-control.

Releasing the enabling device or one of the two hand control devices shall initiate a safety related stop function according to Annex J.

The requirements of ISO 13851 type II or type III B shall be fulfilled. However, the minimum button separation of 260 mm in ISO 13851 can be suspended if there is no way to actuate the two hand devices with one hand, for example by two independent knob type switches or rotary type switches.

NOTE Types of switches, rotary type and knob type, are described in EN 894-3+A1:2008.

The distance requirements of ISO 13855:2010, Clause 8, apply (at least 100 mm).

d) For any accessible hazard zone of the tool changer, information about the residual danger due to the presence of persons shall be provided in the documentation. The same requirements as for the work zone shall also be fulfilled.

e) No hazardous movements of the tool changer shall be initiated from the actuation of any sensor or feedback device while the interlocked guards are open (see IEC 60204-1:2016, 10.1.4).

f) Means shall be provided to prevent hazardous movements of vertical or slant axes under gravity, e.g. brakes (see Annex G).

g) Measures shall be taken to prevent hazards from ejected falling tools under all operating conditions and/or failure of power supply when the interlocked guard is open by securing the tools into the tool changer.

h) All applicable safety functions listed in Table J.9 shall be fulfilled.

5.2.5.3 Additional requirements for workpiece handling mechanisms

If the machine is equipped with automatic workpiece handling mechanisms, the following requirements shall be fulfilled.

a) The positions for operators at workpiece load/unload mechanisms shall be located outside the work zone and away from other hazardous machine movements.

b) Access to hazardous movements from any direction of the workpiece handling mechanisms shall be prevented by fixed and/or interlocked movable guards (ISO 14119:2013, Clause 7 and Annexes A to D).

c) When the interlocked movable guards are open, the workpiece handling mechanism drive(s) and other dangerous movements shall be stopped, and further movements shall be inhibited.

d) Powered movements with movable interlocked guards open and/or protective devices according to 5.2.3.1 suspended shall be initiated and maintained in a position with sufficient distance from the hazard area either by:

— an enabling device together with direction control; In this case, movement shall be at a reduced speed of a maximum of 5 m/min where only an impact hazard exists or where a crushing, shearing or trapping hazard exists either be able to stop in less than 4 mm or be a maximum of 2 m/min; or

— a two-hand control. Releasing the enabling device or one of the two-hand control devices shall initiate a safety related stop function according to Annex J.

The requirements of ISO 13851 type II or type III B shall be fulfilled. However, the minimum button separation of 260 mm in ISO 13851 can be suspended if there is no way to actuate the two-hand devices with one hand, for example by two independent knob type switches or rotary type switches.

NOTE Types of switches, rotary type and knob type, are described in EN 894-3+A1:2008.

The distance requirements of ISO 13855:2010, Clause 8, apply (at least 100 mm).

e) For any accessible hazard zone of the handling mechanism, the same requirements as for the work zone shall be fulfilled.

f) No hazardous machine movements shall be initiated from the actuation of any sensor or feedback device while the interlocked guards or monitored guards are open (see IEC 60204-1:2016, 10.1.4).

g) Means shall be provided to prevent hazardous movements of vertical or slant axes under gravity, e.g. brakes (see Annex G).

h) All applicable safety functions listed in Table J.6 shall be fulfilled.

5.2.5.4 Additional requirements for workpiece setting stations

If the machine is equipped with workpiece setting stations, the following requirements shall be fulfilled.

a) If powered movement of the workpiece setting station is required (e.g. to rotate a pallet with workpiece) while interlocked guards are open or protective devices are suspended (e.g. to clean the workpiece or to carry out measurements) then this shall be possible by using either:

— an enabling device together with a direction control; In this case, movement shall not exceed the maximum of 15 m/min, if only an impact hazard exists. Where crushing, shearing or trapping hazards exist also, the movement shall be able to be stopped within a travel distance of 4 mm or the maximum travel speed shall not exceed 5 m/min; or

— a two-hand control. In this case, the requirements of ISO 13851 type II or type III B shall be fulfilled. However, the minimum button separation of 260 mm in ISO 13851 can be suspended if there is no way to actuate the two-hand devices with one hand, for example by two independent knob type switches or rotary type switches. The distance requirements of ISO 13855:2010, Clause 8, apply (at least 100 mm).

NOTE Types of switches, rotary type and knob type, are described in EN 894-3+A1:2008.

b) For any accessible hazard zone of the workpiece setting station, the requested requirements as for work zones shall be fulfilled.

c) No hazardous machine movements shall be initiated from the actuation of any sensor or feedback device while the interlocked guards or monitored guards are open (see IEC 60204-1:2016, 10.1.4).

d) All applicable safety functions listed in Annex J, Table J.6 shall be fulfilled.

The distance requirements of ISO 13855:2010, Clause 8, apply (at least 100 mm).

5.2.5.5 Additional requirements for powered workpiece clamping mechanisms

If the machine is equipped with powered workpiece clamping mechanisms, the following requirements shall be fulfilled.

a) General requirements

1) Measures shall be taken to prevent unintended loosening of workpieces due to gravity, e.g. by clamps or support devices.

2) The state of the powered workpiece clamping mechanism shall be monitored when connected and if the required actuating force, e.g. monitored by pressure, current, etc., (indirect measuring is possible) is not reached the start of operation shall be prevented, or a stop command shall be initiated if operation has already commenced [see Table J.4 (4.2, 4.3)].

3) No hazardous movement of workpiece clamping device shall be initiated from the actuation of any sensor or feedback device while the interlocked guards or monitored guards are open (see IEC 60204-1:2016, 10.1.4).

4) All applicable safety functions listed in Table J.4 shall be fulfilled.

b) Movement of power operated workpiece clamping device while movable interlocked guards are open shall be:

1) restricted to

i) less than 4 mm clamping stroke (see ISO 13857:2019, 4.2.4.1, Table 4), or

ii) clamping stroke between 4 mm and 20 mm initiated and maintained by means of a safety function see Table J.4, 4.1

2) initiated and maintained by means of an enabling device together with a direction control, where clamping devices are visible;

3) initiated and maintained by means of two-hand control (for two-hand controls, the requirements of ISO 13855:2010, Clause 8, and ISO 13851 for type II, shall be fulfilled); or

4) if it is required to support the workpiece by hand for fixation or adjustment, the movement shall be controlled by a three-step footswitch (category 3) and reduced speed of maximal 5 m/min. The compression of the three-step footswitch leads to an emergency stop or the activation of the movement in the release direction.

c) For magnetically operated workpiece clamping mechanisms, the following requirements shall be fulfilled:

1) the requirements of 5.2.5.5 a) 1) and b) shall be fulfilled;

2) connection via plug and socket.

When the electrical control system is connected to the magnetic clamping plate by means of an electrical plug connection, the workpiece shall be released or clamped by actuating a control device while the control system is connected. The generated clamping force or its nominal value calculated by indirect measurement shall be displayed on the electrical control device prior to disconnection. Axis movements are only permitted after verification that the displayed clamping force meets or exceeds the application requirements and that the clamping

device has been unplugged. Once disconnected, the magnetic clamping force shall remain in the clamping plate. Confirmation that the clamping force continues to meet or exceed the application requirements shall be done at specified intervals according to the manufacturer's specifications by reconnecting the device. Specifications shall be given in the instruction for use (see 6.3.1).

NOTE A safety function according to ISO 13849-1 is not definable for these clamping devices because once they are unplugged, there is no connection to the clamping device.

3) Continuous connection

When the electrical control system is permanently connected to the magnetic clamping plate, the workpiece shall be released or clamped by actuating a control device. The generated clamping force or its nominal value calculated by indirect measurement shall be displayed on the electrical control device. Axis movements are only permitted after verification that the displayed clamping force meets or exceeds the application requirements. Confirmation that the clamping force continues to meet or exceed the initial application requirements shall be done at specified intervals according to the manufacturer's specifications. Specifications shall be given in the instruction for use (see 6.3.1).

4) Connection via sliding contacts

When the electrical control system is permanently connected to the magnetic clamping plate by sliding contacts or brushes, the workpiece is released or clamped by actuating a control device. This method allows multi-purpose applications for milling and turning operations. The requirements of 5.2.5.5 c) 3) are applicable.

The magnetically operated workpiece clamping mechanism can be used without performance level (PL).

NOTE For the time being, there is no performance level available from the manufacturers.

d) For workpiece clamping mechanisms operating with vacuum, the following requirements shall be fulfilled.

1) The requirements of 5.2.5.5 a) and b) shall be fulfilled.

2) For these clamping devices, the safety functions for workpiece clamping mechanisms in Table J.4 (4.2 and 4.3) shall be implemented.

e) It shall be possible to run the machine without workpiece(s) in the fixture in automatic mode of operation with guards closed. In that case, the monitoring of the workpiece clamping may be disabled. The muting function shall have the same safety level as the detection of an incorrectly clamped workpiece [see Table J.4 (4.3)]. The warm up cycle shall be done in MO 1.

5.2.5.6 Additional requirements for workpiece clamping mechanisms in case of turning operation

The general conditions are as follows.

a) Workpiece clamping devices, except collets, shall be clearly marked with their maximum permissible speed. The work table shall be such that manual clamping devices, primarily positive fitting, can be mounted. Mounting of clamping devices which are guided in slots shall primarily be done in such a way that the slots are closed in outside direction or bolts are fitted to open slots to prevent loose clamping devices from being ejected. Design of viewing panels and steel sheets (also roof sections) for jaws with a mass of maximum 2,5 kg shall be in accordance with ISO 23125.

b) When the workpiece is rotating, it shall not be possible to loosen the workpiece clamping device by manual operation, regardless of how the workpiece is clamped. Unclamping shall only be possible during a standstill under safe speed monitor (SSM, n = 0 r/min; see ISO 61800-5-2:2008, 4.2.3.14). Non-return valves shall be provided when hydraulic or pneumatic clamping devices are used.

c) For machines equipped with clamping devices other than collets and where programmable workholding spindle speed is available, a program shall not run in automatic mode unless the following conditions are fulfilled.

   1) Machines shall have facilities for entering and/or validating the maximum workholding spindle speed (milling/turning table) taking into account the maximum permissible speed of the workpiece clamping device.

   2) Rotary movement shall only be initiated when at least one of the following conditions are fulfilled:

      i) clamping device is designed for the maximum permissible speed of the worktable; or

      ii) when the requested rotary speed is higher than the speed limit of the clamping device, the maximum permissible rotational speed shall be limited [see Table J.4 (4.9)].

   3) The clamping device shall be designed such that necessary clamping forces and torques can be transferred to the workpiece.

   4) An actuating force (e.g. by monitoring hydraulic or vacuum pressure) sufficient for the safe clamping of the workpiece shall be maintained until the workholding spindle (milling/turning table) 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.

   5) 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.

   6) For power operated clamping systems, the following applies:

      i) if the required actuating force of power operated clamping device is not reached, initiation of rotary movement shall be prevented. In case of chucks additionally, 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 actuating force is not reached or the necessary remaining stroke is insufficient, starting the workholding spindle drive shall be prevented. If the monitoring of jaw stroke is not possible, other safety measures shall be provided, e.g. a direct measuring of the force on the workpiece (measuring jaws);

      ii) if the workholding spindle (milling/turning table) drive is running and the actuating force falls below a pre-set value, or any other monitoring system of the workpiece clamping is activated, movement shall stop initiated by a safety related stop function according to Table J.4 (4.2). If a clamping device cannot be monitored during machining, alternative protective measures shall be provided, e.g. unbalance detection, additional workpiece retaining device, workpiece present monitoring.

d) For machines with counter workholding spindles 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 workholding 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 counter spindle may 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.

e) No hazardous movements of the workpiece clamping device shall be initiated from the actuation of any sensor or feedback device while the interlocked guards or monitored guards are open (see IEC 60204-1:2016, 10.1.4).

f) All applicable safety functions listed in Table J.4 shall be fulfilled.

5.2.5.7 Additional requirements for swarf/chip conveyor and removal system with hazardous moving parts

If the machine is equipped with swarf/chip collection and removal system, the following requirements shall be fulfilled.

a) Access to hazardous moving parts of swarf/chip collection systems shall be prevented by means of fixed guards. Where operators have a need to access more frequently than once per shift, interlocked movable guards shall be provided. Guards shall be in accordance with ISO 14119:2013 and ISO 14120.

b) Opening an interlocked movable guard, which provides access to hazardous moving parts of a swarf/chip collection and removal system, shall initiate a safety related function according to Table J.11, 11.1, 11.4.

c) If movement of a swarf/chip system with an interlocked guard open is essential (e.g. for cleaning purposes), the movement shall only be:

   1) permitted by means of a hold-to-run control device according to 5.8.6;

   2) permitted by means of an enabling device together with a start device and reduced peripheral speed of maximum 5 m/min. The movement shall be initiated and maintained only while the enabling device is actuated. Releasing the enabling device shall initiate a safety related function according to Table J.11, 11.2, 11.3; or

   3) initiated and maintained by means of two-hand control. For two-hand controls, the requirements of ISO 13851:2019, Clause 7, shall be fulfilled. Distance requirements of ISO 13855:2010, Clause 8, (at least 100 mm) shall be fulfilled. The movement shall be initiated and maintained only while the two-hand control device is actuated. Releasing the two-hand control device shall initiate a safety related function according to Table J.11, 11.2, 11.3.

d) For the swarf/chip discharge area (removal area), the following applies.

   1) Design and safety distances for guards according to ISO 13857:2019, Table 3, where any other additional measures are not provided.

   2) Figure 2 shows a design example with a fixed guard structure for a conveyor that fulfils this requirement. If the measure *Y* in Figure 2 is shorter than 850 mm, additional measures shall be taken to prevent reaching into the hazardous movement of the chip conveyor. The following measures shall be done:

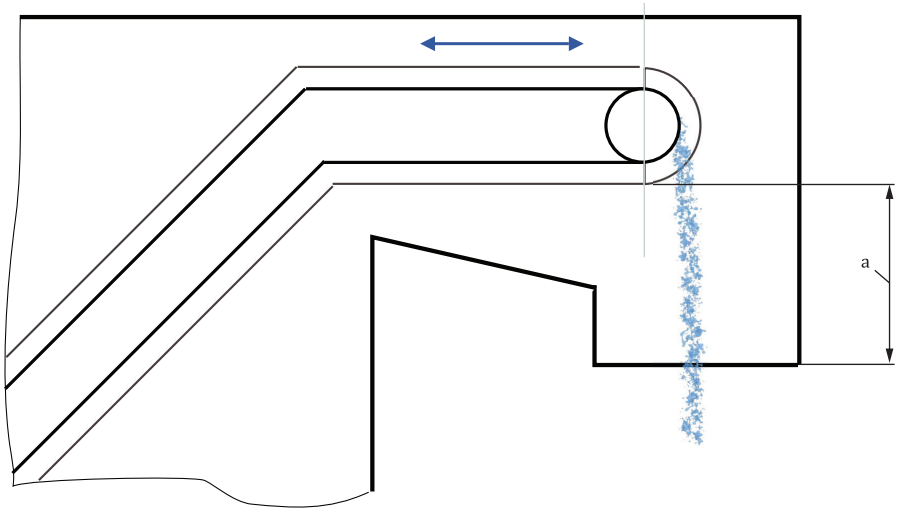
      — funnel dimensions *Y* (see Figure 2) shall be at least 150 mm;

      — design to minimize the chance of chips being held up in the funnel;

      — provide a lockable device to switch off the movement of the chip conveyor with direct visibility at the chip discharge area (see ISO 12100:2010, 6.2.2.1);

   3) The chip conveyor shall be marked as described in 6.2.1 c) 2).

   As stated in 6.2, a yellow and a black marking shall be placed on the floor.



[a] $Y \geq 150$ mm.

Figure 2 — Discharge chute of a chip conveyor

e) Information regarding operating/handling the chip conveyor and container shall be provided in the instruction for use [see 6.3.1 d)].

f) For Group 4 machines only: Means shall be provided to enable the collection and removal of swarf/chips without the need to remove guards (e.g. fixture design to promote swarf/chip shedding, directed flows of metal working fluid).

g) All applicable safety functions listed in Table J.11 shall be fulfilled.

5.2.5.8 Additional requirements for pits

If the machine construction includes pits, the following requirements shall be fulfilled.

a) Pits shall be covered (e.g. floor grids) or secured against persons falling into them. If coverage is not possible, one of the following alternatives in given priority order shall be installed to prevent persons from falling into the pit:

   1) railings in accordance with ISO 14122-1 to ISO 14122-4;

   2) cables with roll-up devices or barrier chains, tapes or cables with a warning sign located at least 1 m, but no more than 2 m in front of the hazardous area.

b) Where access to pits is necessary for observation, maintenance or adjustment purposes, entry into the pit shall be possible via movable guards which prevent machine movement. Where powered machine movements are necessary, machine elements may be moved under the conditions set out in 5.2.4, 5.2.5.3 and 5.2.5.4.

NOTE ISO 13854 contains requirements for minimum distances to prevent crushing.

5.2.5.9 Additional requirements for machines equipped with tailstock

If the machine is equipped with tailstock device(s), the following requirements apply.

a) For the tailstock device(s), the same requirements as for the work zone shall be applied.

b) All applicable safety functions listed in Table J.5 shall be fulfilled.

5.2.5.10 Additional requirements for machines equipped with bar feed

If the machine is equipped with bar feed devices, the following requirements apply.

a) For the bar feed device, the same requirements as for the work zone shall be applied.

b) All applicable safety functions listed in Table J.7 shall be fulfilled.

5.2.5.11 Additional requirements for compressed air for cleaning and measuring processes

If the machine is equipped with compressed air, the applicable safety functions listed in Table J.22 shall be fulfilled.

5.2.5.12 Additional requirements for pallet clamping and movements on machines with milling and turning operation

If the machine is equipped with pallet clamping and movements, the applicable safety functions listed in Table J.8 shall be fulfilled.

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 document.

   2) The following requirements apply:

      i) IEC 60204-1:2016, Clause 7, for protection of equipment, against short circuit, feeder circuit excluded and overloading. The machine manufacturer shall provide the user with information on how to provide the protection against short circuit of the feeder circuit (see 6.3.8);

      NOTE The protection against short circuit of the feeder circuit is not up to the machine manufacturer.

      ii) IEC 60204-1:2016, Clause 8, for equipotential bonding;

      iii) IEC 60204-1:2016, Clause 12, for conductors and cables;

      iv) IEC 60204-1:2016, Clause 13, for wiring practices;

      v) IEC 60204-1:2016, 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. The access to live parts shall only be possible under the conditions of IEC 60204-1:2016, 6.2.2). The risk of fire is not considered significant for machines where power circuits are protected against over current (see IEC 60204-1:2016, 7.2.2).

b) For indirect contact with electrical equipment, the machine manufacturer shall provide the protective bonding system of the machine up to the PE terminal. It shall also provide the user with information on how to complete protection against electrical shock due to indirect contact (see 6.3.8).

   NOTE See IEC 60204-1:2016, 3.1.34, for the definition of “indirect contact”.

c) The protection of all electric components against ingress of foreign objects, liquids, dust, coolants, lubricants and swarf shall be adequate taking into account the external influences under which the machine is intended to operate (in accordance with IEC 60204-1 and IEC 60529).

5.4 Specific requirements resulting from noise hazards

When designing the machine, the available information and technical measures to reduce noise at its source shall be taken into account (see, for example, ISO/TR 11688-1, ISO/TR 11688-2). The design shall take into account noise from every possible source. Appropriate technical measures for reducing noise at the main sound sources of machines are listed below:

a) usage of low-noise machine components;

b) transmission noise by gearbox damping;

c) pneumatic exhaust through silencers;

d) power generation sounds by damping or absorption;

e) noise during cutting process by damping or absorption inside the work zone enclosure;

f) during workpiece/tool change by damping or absorption inside the work zone enclosure.

The above list is not exhaustive. Alternative technical measures for noise reduction with identical or greater efficiency may be used.

Where noise levels shall be reduced beyond those achievable by design at source, the machine shall be provided with protective measures (e.g. noise enclosures, screens fitted to the machinery, silencers).

Operating conditions for noise measurement shall be in accordance with Annex K. 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 6.3.6.

5.5 Specific requirements resulting from radiation hazards

a) For low-frequency radiation, high-frequency and microwaves radiation, see 5.8.8. See also IEC 61000-6-2:2016 and IEC 61000-6-4 for more information.

b) Built-in laser feedback systems shall be designed to prevent exposure to beam paths or specular reflections in accordance with IEC 60825-1:2014.

c) Strong magnetic fields, which may be encountered at e.g. linear drives, can cause irreversible injuries. Through constructive measures, e.g. guards, direct access during normal operation shall be prevented.

Warning signs according to ISO 7010 to emphasize the residual risk shall be attached in a position where the operator can see them.

NOTE Persons particularly at risk are those with cardiac stimulator and prostheses which react to magnetic fields.

5.6 Specific requirements resulting from material or substance hazards

5.6.1 Combustible coolants

Machinery designed to make usage of combustible coolants shall be equipped with devices which minimize the risk from the production of combustible mixtures or an ignition source, especially in MO 1.

a) Dimension of coolant circuit shall be such (pipe cross section, reservoir, pumps, nozzle forms and positioning, etc.) that a sufficient and continuous amount of coolant supply is ensured at processing site.

b) Preventing start-up of machines working cycle, when coolant supply is not functioning properly.

c) In case of a coolant supply not functioning properly, the machining process shall automatically be brought to a stop in an appropriate manner, e.g. separation of workpiece and tool and shut-off of tool drives.

d) Use of adequate exhaust systems

The suction power shall be as such that at least a negative pressure (below the atmospheric pressure) in the work zone is maintained to securely prevent coolant vapours and aerosols from escaping the work zone.

In case of an incorrectly functioning exhaust system, start-up of a machines working cycle shall be prevented or a currently running machining process shall automatically be brought to a stop in an appropriate manner, e.g. separation of workpiece and tool and shut-off of tool drives. For safety functions, see Table J.14.

Piping of exhaust systems shall be designed so that fluids flow back into the machine, so that the pipes are empty.

All metal parts within the work zone including pipes of exhaust system shall be fully connected to the protective bonding circuit to prevent electrostatic charge.

Vents within the work zone shall be as such that swarf/chips or greater amounts of fluid cannot be sucked in.

If fire and explosion risks cannot be excluded by these systems, additional measures for limiting the consequences of fire and explosion events shall be provided in accordance with ISO 19353:2019 and EN 1127-1.

These include the following measures:

— pressure-resistant enclosure of the work zone including windows and, if necessary, pressure relief in a direction not dangerous to personal;

— preventing flames and hot gases from work zone escaping into the operating area outside the work zone and vicinity of the machine, e.g. flame arresting labyrinth seals on movable parts of the guards (circumferential). For examples, see F.2;

— adequate fire extinguishing devices;

— the machine, including the control system, shall be designed so that connecting fire detecting devices, e.g. fire extinguishing systems, fire alarm, pressure relief valves, etc., are possible according to the manufacturer's recommendations (interface description).

For accessible machines and use of fire extinguishing devices with oxygen suppressing quenching gases, mechanical interlocking capability for the quenching gas supply shall be provided. Additional measures shall be taken to prevent personnel from being trapped within the work zone, e.g. possibility for unlocking the door from the inside without the need of power supply by means of a guard locking device with an escape release (see ISO 14119:2013). In addition, the extinguishing system shall be provided with a release button which shall be actuated only from outside the work zone. The automatic extinguishing system is only activated after the release button has been actuated and can only be set after a sensor signal has been triggered, in a condition where quenching gas can stream into the work zone.

NOTE 1 It can otherwise be possible to unintentionally close and lock the door from the inside while the machine is switched off and quenching gas can perhaps stream inside.

NOTE 2 For further information, see also Annex E.

For machines which are intended to be connected to a central exhaust system, measures or devices shall be provided, which in case of fire:

— prevent fire from spreading into the central exhaust;

— prevent further air flow into the work zone; and

— prevent exhaust of extinguishing agent, e.g. flame arresters (see example in F.3), butterfly valve for exhaust air.

Integrated decentralized exhaust systems shall automatically shut off in case of fire or explosion.

e) All applicable safety functions listed in Table J.14 shall be fulfilled.

NOTE 1 Further measures of risk reduction depend on the actual conditions of use of the machine and need to be considered individually.

NOTE 2 Accumulation of fluid and dried materials and contact with hot swarf/chips within the piping can cause a fire.

5.6.2 Minimum quantity lubrication (MQL)

For minimum quantity lubrication, the risk of fire and explosion is primarily determined by the amount of flammable swarf/chips and dusts.

The flashpoint of minimum quantity lubricant used shall be considered. In principle, lubricants with a flashpoint of at least 150 °C shall be used. When used in accordance with its intended use, evolution of a dangerous explosive air/vapour mixture is not likely to occur if the consumption rate remains below 100 ml/(m^3/h). If this is not ensured, a machine extraction system is mandatory.

5.6.3 Dry processing and combustible dust

A mechanical interface for an air-extraction system is mandatory [see 6.3.1 r) for documentation requirements].

An explosion risk shall be considered for accumulations of combustible dust (for example, for graphite dust) and especially for light metal dusts, e.g. aluminium, titanium and magnesium. Dispersion of deposited combustible dust can lead to a hazardous explosive atmosphere. If ignition by aluminium, titanium and magnesium dust is to be expected during the intended use of the machine, suitable gases or dry powders such as CO_2 or inert gas shall be used in the extinguishing system.

A higher risk of fire exists in areas in which great amounts of combustible swarf/chips and dusts emerge and accumulate. In addition to the work zone of the encapsulated system, the pipes and filter area of the exhaust system in which fine dust can be separated and dispersed shall also be considered. If fine dry combustible dust particles are cleaned up or dispersed, a possible risk of explosion exists. In these areas, it is not permitted to use compressed air as this causes dispersion of the dust particles during machining (see Annex F).

Machining shall be stopped in case of failure of the swarf/chip removal or exhaust within sealed machines.

5.6.4 Requirements for biological or microbiological hazards

The following are the requirements for biological or microbiological hazards:

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

b) to avoid stagnant areas remaining within the machine, metalworking fluid shall drain under gravity from the machine towards the reservoir. Otherwise, elevating pumps with level monitoring shall be provided to pump the metalworking fluid from the machine back into the reservoir;

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

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

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

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

g) metalworking fluid reservoirs shall have covers designed to prevent the ingress of foreign matter;

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

i) where a 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 shall take into consideration the internal airflows generated by the machine when in normal operation to enable effective operation of the extraction system;

j) provision shall be made to empty metalworking fluid reservoirs completely;

k) means shall be provided to enable, with the least possible exposure of operator to the fluid:

   — fluid samples to be taken;

   — sumps and pipework to be cleaned; and

   — filters to be changed.

5.7 Specific requirements resulting from neglect of ergonomic principles hazards

Machines shall be designed in accordance with the ergonomic principles given in:

— EN 614-1+A1;

— ISO 12100;

— ISO 14738:2002;

— ISO 15534-1;

— ISO 15534-2;

— EN 1005-1+A1:2008, EN 1005-2+A1:2008, EN 1005-3+A1:2008 and EN 1005-4+A1:2008.

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

   1) workpieces, tooling and accessories shall be easy to move. For requirements on lifting equipment, see 6.3.1 i);

   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 movable guards are partially 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 9241-400, ISO 9241-410, EN 1005-2+A1 and EN 1005-3+A1);

   4) control devices to operate clamping or gripping devices (e.g. drawbars, chucks) shall be positioned to avoid excessive reaching while supporting the weight of the tool or workpiece (e.g. application of foot controls) (see ISO 9355-3:2006, Clause 4);

5) moveable guards shall be power-operated where use of them will lead to repeated excessive effort (see also ISO 12100:2010, 4.2.2).

b) For adequate 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 reservoirs, shall be chosen to satisfy the ergonomic principles given in EN 614-1+A1:2009, ISO 9241-400, ISO 9241-410; ISO 9355-1:1999, ISO 9355-2:1999, ISO 9355-3, EN 1005-2 and ISO 13855.

c) Work zone lighting shall be provided with at least 500 lx at the tip of the tool.

d) For design location or identification of manual controls, input devices (e.g. keyboards, keypads and push buttons) shall be in accordance with ISO 9355-1:1999 and ISO 9355-3.

e) For design or location of visual display units, screen displayed information shall be clear and unambiguous. Reflections and glare shall be minimized (see ISO 9241, ISO 9355-1:1999 and ISO 9355-2:1999.

f) Equipment and accessories indicated in the instruction handbook and not readily available, shall be provided for adjusting and maintaining the machine.

5.8 Specific requirements resulting from failure or disorder of the control system

5.8.1 General

The requirements are the following:

a) Electrical control systems and SRP/CS shall be designed in accordance with:

— IEC 60204-1;

— ISO 13849-1; and

— ISO 13849-2:2012.

NOTE Designing the electrical control system according to IEC 62061 can generally achieve the same safety level of any safety function in Annex J as the application of ISO 13849-1.

b) pneumatic systems shall be in accordance with ISO 4414;

c) hydraulic systems shall be in accordance with ISO 4413;

d) safety-related software shall be protected against unauthorized reconfiguration. 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. This may be achieved using a password, key switch or adequate access device.

5.8.2 Starting

The requirements for starting are the following.

a) Requirements for starting are described in 5.2.4 depending on active Operating Mode. Where multiple main control cycle start devices are provided and the operators can therefore put each other in danger, only one shall be enabled at any time [see ISO 12100:2010, 6.2.11.8 e)]. If it is possible to start the same hazardous element by means of several controls, the control circuit shall be arranged that only one control is effective at any given time (see Table J.15, 15.2 for switching control sovereignty).

b) In MO 1 (automatic mode), machining shall only be started or restarted when the guards are closed and protective devices active by actuation of the start device provided for that purpose, or if the requirements for guards with start function in accordance with ISO 12100:2010, 6.3.3.2.5, are fulfilled, the closure of a movable interlocked guard can result in a restart of moving machine parts.

c) Unexpected start-up of hazardous movements shall be prevented in accordance with ISO 14118:2017, Clause 6, when the interlocked movable guards are open.

5.8.3 Normal stop

a) Machinery shall be fitted with a control device whereby the machinery is be brought to a complete stop in cat 0 or cat 1 (for machines group 1 and 2, Table J.17, 17.8 and for group 3 and 4 machines see Table J.17, 17.6).

b) Machines shall have a stop function according to IEC 60204-1:2016, 9.2.2.

c) The machinery's stop control shall have priority over the start control.

5.8.4 Emergency stop

Each machine shall be fitted with one or more emergency stop devices. When a sequenced shutdown is required, the emergency stop functions shall be category 0 stop or category 1 stop in accordance with IEC 60204-1:2016, 9.2.3.4.2, ISO 12100:2010, 5.5.2 and ISO 13850:2015.

An emergency stop function shall be initiated by one emergency stop device or more which shall be in accordance with IEC 60204-1:2016, 10.7, and ISO 13850. An emergency stop device shall be provided at each operator's position including:

a) the main control panel;

b) each portable control panel(s) (if provided); and

c) inside the tool magazine or workpiece setting station, where whole body access to the enclosure is possible, but it can be omitted if presence is short (see 3.1.17) and it is possible for a person to release oneself from inside the enclosure.

Where emergency stop devices are detachable, the requirements of ISO 13850:2015, 4.3.8, shall be followed.

Safety functions listed in Table J.16 shall be fulfilled.

5.8.5 Manual reset function

After a stop command has been initiated e.g. by a safeguard, the stop condition shall be maintained until safe conditions for restarting exist.

The re-establishment of the safety function by resetting of the safeguard cancels the stop command. This cancellation of the stop command shall be confirmed by a manual, separate and deliberate action (manual reset).

The manual reset function shall

— be provided through a separate and manually operated device within the SRP/CS,

— only be achieved if all safety functions and safeguards are operative,

— not initiate motion or a hazardous situation by itself,

— be by deliberate action,

— enable the control system for accepting a separate start command,

— only be accepted by edge detection of the input signal from the actuator (see Table J.17, 17.10).

The reset actuator shall be situated outside the danger zone and in a safe position from which there is good visibility for checking that no person is within the danger zone.

Where the visibility of the danger zone is not complete, a special reset procedure is required.

NOTE One solution is the use of a second reset actuator. The reset function is initiated within the danger zone by the first actuator in combination with a second reset actuator located outside the danger zone (near the safeguard). This reset procedure needs to be realized within a limited time before the control system accepts a separate start command.

5.8.6 Safety related parts of control system (SRP/CS)

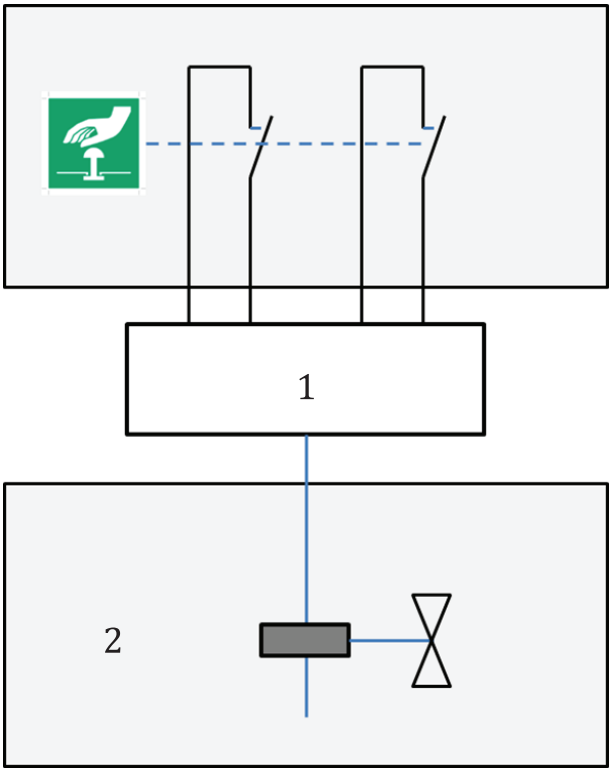
The combination of safety related parts of a control system starts at the point where safety related signals are generated (e.g. emergency stop device, position switch) and ends at the outputs of the power control unit (e.g. main contacts of a contactor). If no hazards occur in de-energized state, power units such as motors or actuators are not considered to be parts of SRP/CS. If external forces take effect (e.g. on vertical axes), power units shall additionally be equipped with safety related parts (e.g. non-return valve on actuators, additional mechanical brake).

Safety functions shall meet the requirements for the performance level of ISO 13849-1:2015 as given in Tables J.2 to J.22. In addition to the safety functions given in Annex J, the following applies.

a) Hold-to-run control device: If the required performance level (PLr) as stated in Annex J cannot be achieved by the sole application of a hold-to-run control device, a combination of hold-to-run control and enabling device shall be applied (that complies with PLr = d, category 3 according to ISO 13849-1:2015).

b) Electronic handwheel: If the required performance level (PLr) as stated in Annex J cannot be achieved by sole application of an electronic handwheel a combination of electronic handwheel and enabling device shall be applied (that complies with PLr = d, category 3 according to ISO 13849-1:2015).

c) Emergency stop device: The emergency stop device shall be wired from input to logic in category 3 according to ISO 13849-1:2015 (see Figure 3). See Annex J, Table J.16.



Key

1 safe logic

2 output

Figure 3 — Schematics of an emergency stop circuit

d) Enabling device and wiring: Category 3 according to ISO 13849-1:2015 shall be used.

5.8.7 Monitoring rotational speed limits and limits of linear and rotary movements

The following requirements apply only to machines of Group 2, Group 3 and Group 4 (they do not apply to Group 1 machines).

a) The maximum permissible spindle speeds and other linear speeds and rotary speeds shall be monitored in accordance with Table J.17, 17.3 and 17.4 in MO 2 and MO 3 with guards not closed.

b) Movements caused by electrical, hydraulic or pneumatic, which are not required to be monitored, shall only be initiated and maintained in conjunction with an enabling device while guards are not closed. The speeds shall be reduced according to the selected MO (see 5.2.4) and, if applicable, the requirements stated in 5.2.5 for optional or additional equipment shall also be fulfilled.

c) If the maximum permissible rotary speed or the speed limit of a monitored motion is exceeded, a stop shall be initiated automatically.

5.8.8 Requirements for electromagnetic compatibility of electrical equipment

The requirements for electromagnetic compatibility of electrical equipment are the following.

a) Immunity: Electronic and electrical components used in the machine shall be designed in accordance with IEC 61000-6-2. Regarding electro static discharge (ESD), the machine shall be designed in accordance with IEC 61000-4-2:2008 and for burst with IEC 61000-4-4:2012.

b) Emission: Electric/electronic design shall apply technical information and physical measures to limit electromagnetic emissions depending on required local prerequisites:

— mixed environment, light-industrial environment, IEC 61000-6-3; or

— industrial environment, IEC 61000-6-4.

EN 50370-1 and EN 50370-2 are also applicable.

5.9 Specific requirements resulting from failure of any power supply

Requirements at the event of 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 voltage and/or pressure dependant devices).

c) Restoration of the energy supply shall not result in the machine automatically restarting according to Table J.17, 17.5 (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. See Annex G for requirements regarding the safety control function to prevent unintended descent of a vertical or slant axis.

e) Systems shall be designed so that a line rupture in any circuit (e.g. broken wire, pipe or hose) does not result in any hazardous situation (see IEC 60204-1, ISO 4413 and ISO 4414).

f) Means shall be provided for the isolation of the energy supply (see ISO 4413:2010, 5.4.7.2.1; ISO 4414:2010, 5.2.8 and IEC 60204-1:2016, 5.3). For the dissipation of stored energy, see also ISO 14118:2017, 5.3.

g) If the machine is provided with its own hydraulic unit and/or pneumatic compressor, the electrical disconnection of the machine shall also disconnect the electricity for the motor of the pump and/or the compressor. If the machine is supplied with external hydraulic and/or pneumatic energy, the machine shall be provided with reliable manually operated and lockable devices (e.g. ball valve) which fulfil the requirements of ISO 14118:2017, Clause 5, for a disconnection from the supply. If automatic dissipation of energy is not possible due to isolation (see ISO 14118:2017, 5.3.1.3), facilities for discharging the remaining pressure shall be provided. These devices may include valves but the disconnection of pipes is not permitted.

NOTE In case of power failure or errors in the control or the power switches, coast of spindle drives cannot be excluded. Also, slight sag of gravity loaded axes cannot be prevented due to the response time of the mechanical holding brake.

5.10 Specific requirements resulting from errors of fitting hazards

Any part dismountable by the user for setting or maintenance purposes (e.g. tool holder and mechanical devices), shall have provisions for preventing errors of fitting, e.g. pins, asymmetrical mounting (see 6.3.1).

5.11 Specific requirements resulting from ejected fluids or parts

5.11.1 General requirements

Guards shall be designed in accordance with ISO 14120:2015, 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.

5.11.2 Ejection of parts — Guard strength

Fixed and/or adjustable guards shall be provided to contain chips/swarf and/or metalworking fluids and parts and to deflect them towards the collection area. The area of the work zone of the machine shall be surrounded by guards in such a way that ejected chip/swarf and/or metalworking fluids and parts are intercepted. The guards shall be designed in such a way that accumulation of swarf/chips and fluids on the guard structure is prevented.

Standardized calculations shown in Annex A shall be applied to determine the potential kinetic/impact energy which are generated by ejection of parts. The guard strength is a function of guard thickness and guard material. Annex B shows examples of minimum guard thicknesses depending on used materials to withhold an impact energy generated by a projectile weighing 100 g.

NOTE 1 Shooting equipment is illustrated in Annex B.

For machines that provide additional operations, such as turning operation or grinding operation, similar calculations are provided in the relevant standards (for turning operations use calculations of ISO 23125:2015, Annex A, and for grinding operations use calculations of ISO 16089). The operation that requires the highest guard strength shall be used for the final guard design of the machinery.

If the machine is equipped with grinding operation, the applicable safety functions, listed in the Annex J, Table J.21, shall be fulfilled.

In addition, measures regarding clamping (see 5.11.3, 5.2.5.5, 5.2.5.6, Table J.4 and Table J.2) and following proper instruction for use (see Clause 6) are given to reduce the risk of ejection.

NOTE 2 The hazards associated with ejected workpieces and parts of the machine are significant. This document uses current state-of-the art methods to determine guard thicknesses which retain the majority of these within the enclosure in the event of an incident which has been used successfully for many years (see Annex A). However, it is a physical impossibility to guarantee that all types of such items will be retained (dependent on their weight, size and ejection energies, etc.).

Where guards are fitted with viewing panels which are also intended to contain ejected parts, special consideration shall be given to the selection of materials and methods of fixing (see ISO 14120:2015, 5.4.2). Materials such as polycarbonate, which have a reduction in impact resistance over time (aging) due to contamination (e.g. by lubricants, metalworking fluids, cleaning agents, solvents) and abrasion, shall be provided with additional protection (e.g. sealed multi-layer or laminated constructions) or additional thickness to counter this harmful effect during the anticipated service life of the machine. Information on guards with reinforced viewing panels (e.g. additional thickness) along with replacement/maintenance intervals shall be given in instruction for use.

5.11.3 Power-operated workpiece and tool clamping

a) Power-operated workpiece and tool clamping shall be designed to avoid risks of ejection due to intervention of the emergency stop or failure of the power supply. Tool/workpiece clamping force shall remain intact until standstill (e.g. by using non-return valves on the hydraulic system or a self-locking clamping device).

b) The tool clamping cylinder shall be monitored so that a failure to achieve correct registration or clamping of the tool shall inhibit spindle start or stop a running spindle in all modes of operation. Unclamping of the tool by actuation of the tool clamping cylinder during spindle rotation shall be prevented.

c) The workpiece clamping cylinder of powered workpiece clamping mechanism shall be monitored at least indirectly (e.g. indirect hydraulic pressure measurement via a rotary coupling system) so that a failure to achieve correct registration or clamping of the workpiece shall inhibit start-up in all modes of operation. Unclamping of the workpiece by actuation of the workpiece clamping cylinder during spindle rotation shall be prevented.

d) All applicable safety functions listed in Table J.2 and Table J.4 shall be fulfilled.

5.11.4 Additional requirements for Group 3 and Group 4 machines

Some of group 3 and group 4 machines are provided with machine tables large enough (see Figure D.6) to machine a workpiece and prepare the machining of another workpiece at the workpiece setting station at the same time, while the machine is operated in MO 1. In this case, additional requirements are as follows:

— Both the work zone and workpiece setting station shall be separated by interlocking guards according to ISO 14119:2013.

— The guards shall extend up to the roof of the machine or at least shall be 1 800 mm in height from the operator position floor and have the width of the machine table.

— Unintended movement of machine parts into an adjacent non-active work zone shall be prevented. The SRP/CS for preventing unintended movement shall be in accordance to Table J.17.

5.12 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 fastening is one of the measures used to help prevent overturning, manufacturers shall specify the fastening and foundation requirements necessary in the information for use, see 6.3.8.

5.13 Requirements resulting from slips, trips, and fall of persons hazards

a) Places of work and means of access on machines (such as 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. Warnings about hazards and precautions shall be given in the information for use [see 6.3.1 w)].

b) To avoid contamination of floors by coolants, the work zone shall be designed to prevent coolant from escaping (see 6.3.8).

5.14 Requirements resulting from accessibility for maintenance or troubleshooting on high parts of the machine

Where frequent access is required (i.e. at least once per shift), permanent means of access, such as fixed working platforms with fixed railings and toe boards against falling hazards in accordance with ISO 14122-2 or stairways and ladders according to ISO 14122-3, shall be provided.

If only occasional access is required and the height is above 2 m, one or both of the following means shall be provided: supports for safety belt and/or means to attach movable ladders. For occasional access, see also Clause 6.

5.15 Requirements for machinery with operator cabins and perimeter fencing

5.15.1 General

Due to geometrical dimensions of some machinery, it is in some cases necessary in order to operate the machinery properly that:

a) one or more person(s) need to enter the work zone;

b) operator(s) need to leave or access the control cabin, which is in the work zone; or

c) large workpieces (2 m or more in heights) need to be machined.

In these cases, additional requirements need to be fulfilled. Information regarding these requirements shall be described in the instruction for use section (see 6.3).

5.15.2 Overall concept for entering/leaving machinery

The overall concept of entering and leaving the machinery shall be in such a way that the first person entering the machine shall actively allow other persons to enter the safeguarded zone of the machine. This can be done by controlling one of several interlocked guards with guard locking, in combination with a security device, mainly with an electronic key system or equal measures.

A concept to leave/access the control station (e.g. cabin) from/to a non-hazardous area outside the guards/perimeter fencing during machine operation shall be worked out (see also Annex H).

NOTE Such concept aims that the person inside the machine actively allows other persons to enter the machine and is therefore aware of who and how many other person(s) are inside the safeguarded zone of the machine at any time.

Access to the cabin in MO 1 shall not require entry into the hazard zone enclosed by perimeter fencing or other protective devices. Where this is not possible, because of the machine configuration or other operational constraints, additional safeguarding for an access route to the operator position shall be provided.

The overall concept of leaving the control cabin in MO 2 or MO 3 shall ensure that the person, which is outside the control cabin, but within the safeguarded zone, has the direct control of movements of the machine.

Secondly, it is to ensure that the person is wearing safety belts by stepping on workpieces in height.

5.15.3 Requirements for moveable/adjustable operator cabins and operation platforms

5.15.3.1 General

For design, testing, marking, documentation for use and maintenance requirements, refer to EN 528. The following specifications take precedence over EN 528 in case of conflicts.

5.15.3.2 Strength and stability

Cabins/platforms shall be designed so that any failure due to fatigue, aging, wear and corrosion is prevented. The rated load (excluding persons), the number of persons and the maximum permitted load to travel on the machine shall be stated by the manufacturer.

Fixed or moving cabins/platforms shall be designed with a safety factor of 1,3 for stability.

An operator platform/cabin shall be designed and constructed to withstand the overload in the static tests without permanent deformation. For static testing procedures, the operator platform/cabin shall withstand 1,25 times its load. For dynamic testing procedures, the operator platform/cabin shall withstand 1,1 times its load (see EN 528:2009, 9.5.1, and EN 528).

Signs shall be placed at the operator platform/cabin for its maximum allowable load capacity and the maximum number of people allowed on platform or in cabin at one time.

5.15.3.3 Limiting the load

Operating platforms/cabins shall be fitted with a device to prevent a hazardous movement and warn the operator when the maximum permissible load capacity or the permissible load or overturning moment is exceeded.

5.15.3.4 Functional design

The walk-in of the operator platform/cabin shall have a minimum width of 600 mm, preferably 800 mm, and headroom shall be at least 2 100 mm (see ISO 14122-2).

Operating platforms/cabins shall be fitted with skirting and be equipped for fall protection with a railing of at least 1 100 mm in height, if the height of the operator platform/cabin is higher than 500 mm (see ISO 14122-2 and ISO 14122-3).

Surfaces of floors of operating platforms/cabins shall be as such that they reduce the risk of slipping. The difference in height of adjacent flooring at the same level shall not exceed 4 mm (see ISO 14122-2 and EN 528:2009, Clause 6).

For protection of operator(s) from high pressurized media or the ejection or falling of objects, the platform/cabin shall be equipped with screens that absorb the energy of those predictably thrown objects (see 5.11).

The operator platform/cabin shall be adequately illuminated (300 lx) and sufficiently ventilated.

Access to the operator platform/cabin shall be possible without any risk. Interlocked guards shall be provided to protect against crashes and prevent access to hazardous movements. Interlocked guards shall be secured against accidental opening and shall only open in one direction in order to prevent any risk of falling.

Moving parts shall be designed in a way that squeezing, pulling, shearing, etc., cannot occur.

The operator platform/cabin shall be designed so that vibrations cannot cause any harm to the health of passenger(s) respectively operator(s).

If access to the machine from an operating platform/cabin is required, the access options to hazardous zones of the machine shall be designed in accordance with the requirements of MO 1, MO 2 and MO 3.

If it is required to open a door of the operator platform/cabin in a raised position (e.g. to step on a workpiece), the platform/cabin shall be equipped with suitable anchor devices, designed and tested according to EN 795.

When the platform/cabin is raised, the operator(s) shall confirm by appropriate means to wear a suitable fall protection device before the door can be opened.

During normal operation, the area under the operating platform/cabin shall be inaccessible. If there is a crushing hazard to persons situated under or above the operator platform/cabin or between the platform and other stationary parts of the machine, means shall be provided to block or turn off the motion of the operator platform/cabin for sufficient clearance.

5.15.3.5 Actuators, limitation of movement

The platform/cabin shall be equipped with hold-to-run devices to control the movements. Those actuators have priority over all other controls, except the emergency stop devices. The movement of the operator platform/cabin shall only be possible with doors closed. An acceleration or deceleration of the movement of the operator platform/cabin shall not cause any hazard.

In order to prevent collisions between the operator platform/cabin with any obstacles, and against collisions of moving obstacles with the operator platform/cabin, appropriate means to shut down the movement shall be provided (e.g. ESPE, PSPD). If the colliding speed is lower than 15 m/min, no means are necessary.

5.15.3.6 Protective measures and safety devices

A mechanism and/or device shall be provided to bring the platform/cabin to a standstill without exposing persons to hazardous situations. This mechanism and/or device shall also function at maximum load and maximum speed.

In case of power failure, means shall be provided, which allow leaving the platform/cabin, even in its elevated position [e.g. through emergency descent by means of a ladder or depressurization or by uninterrupted power supply (UPS) supplying energy for the required movements].

In case of power failure or prolonged shutdown or changes in environmental conditions (e.g. temperature), the platform/cabin shall not independently change its position if this leads to a collision. If necessary, appropriate holding devices, monitoring devices and readjustment devices shall be provided.

Means shall be provided that allow the control of the platform/cabin, which is control of motion and the opening of doors (e.g. to release people), from the ground level and outside the platform/cabin.

If the cabin is in an elevated position higher than 2 m above ground level, the following shall apply.

— All operator(s) shall have the possibility to sling the safety belt onto the inside of the control cabin.

— The operator(s) left in the cabin shall confirm, before leaving the cabin, that all person(s) inside the cabin wear the safety belt. Without confirmation, it shall not be possible to open the interlocked guard of the control cabin.

— No movement of the machine shall take place when the interlocking guard with guard locking of the control cabin is opened.

— The initiation of movements shall only be possible with a movable control station (e.g. pendant) featuring an enabling device and which has precedence over the control panel within the cabin.

5.15.3.7 Testing and commissioning

Appropriate measures to ensure proper functioning of the platform/cabin shall be taken when first putting it into service. That requires performing static and dynamic tests of the platform/cabin. In case the assembling of the platform/cabin cannot be done at the manufacturing site, appropriate measures shall be taken at the place of use.

The manufacturer of the platform/cabin shall provide information in the documentation on what kind of service inspections are required and what intervals those inspections shall take place.

5.15.3.8 Additional requirements for cabins located in the work zone

When the machine operator requires access to the work zone from the protected (fixed) operating position (cabin), e.g. for setting purposes, the cabin shall be designed so that access is possible through an interlocked movable guard from within the cabin. Alternatively, the movement of a movable control station from the cabin position shall have the same effect as the interlocked guard above. Operation of the machine in MO 1 (automatic mode) shall only be possible when the movable control station (above) is relocated in the cabin. Any other powered movement of machine elements shall only be achieved by selection of the appropriate MO (see 5.2.4).

Where a cabin is provided for Group 2 and Group 3 machines, it shall be possible to access/leave the cabin in MO 1 (automatic mode) without any risk.

If the operator leaves the cabin from a safe position (e.g. rear area of the machine) and the cabin is moving not more than 5m/min, it is possible to leave without stopping the operator cabin (see Table J.17). Otherwise, the cabin movements shall be stopped before leaving. When leaving and returning to the cabin, the acceleration shall not exceed 0,5 m/s^2.

For accessing and leaving the cabin the following applies.

— During operation in MO 1, it shall be possible to traverse the cabin to the position in which the cabin is accessible.

— If it is necessary to exit at a position other than the normal position (for example, for measuring purposes), the requirements of 5.15.2 shall apply.

The exit shall be at the side which is directed away from the machining process. If the cabin is elevated, an interlocked guard with guard locking shall be activated in order to prevent falling (see examples in Annex H).

Where a cabin is provided for Group 2 and Group 3 machines, it shall be possible to leave and return to the cabin in MO 2 and MO 3 without any risk. During operation in MO 2 or MO 3, it shall be possible to have access to the workpiece in each position.

5.15.4 Requirements for perimeter fencing

When access to the work zone is prevented by perimeter fencing, all the provided access points shall be fitted with moveable interlocked guards.

NOTE Annex H gives an example of an access concept.

5.16 Requirements for teleservice

For machines with teleservice capability, the following requirements apply:

a) a secure connection line, e.g. VPN, shall be used for teleservice;

b) during telecontrol, the connection line shall periodically be supervised to ensure it is active;

c) whenever communication lines pose a problem for the teleservice, the lines shall be terminated (e.g. after a timeout);

d) the teleservice functions shall be enabled from the machine side;

e) any single machine shall be readily and clearly identifiable by the teleservice remote operator (e.g by IP address);

f) a confirmation of the above from the operator shall be required before starting the telecontrol function;

g) the emergency stop-control function and all safety functions at the machine shall take precedence over any command issued from remote;

h) teleservice operation shall not activate mode selection and shall neither suspend nor reset any safeguard or safety function;

j) indication that the teleservice mode is activated shall be provided at the machine, e.g. by a message on the screen.

NOTE For instruction manual see 6.3.13.

5.17 Verification of the safety requirements and/or protective measures

Verification of conformity with the safety requirements and/or protective measures shall be done in accordance with Table 3.

Table 3 — Verification methods

Clause/ sub-clause	Item	Verification method				
		Visual inspection	Functional test	Measurement	Calculation	Examination of documentation
5	**Safety requirements and/or measures**					
5.1	General requirements					
5.1.1	General	X	X			X
5.1.2	**Required characteristics for guards of all machine groups**					

[a] Only test 1 for the continuity of the bonding circuit according to IEC 60204-1:2016, 18.2, and functional test according IEC 60204-1:2016, 18.6, applies.

Table 3 *(continued)*

Clause/ sub-clause	Item	Verification method				
		Visual inspection	Functional test	Measurement	Calculation	Examination of documentation
5.1.2.1	General					X
5.1.2.2	Fixed guards	X		X		X
5.1.2.3	Manually operated moveable interlocked guards	X	X			X
5.1.2.4	**Power-operated moveable interlocked guards**					
5.1.2.4.1	General		X			X
5.1.2.4.2	Power-operated movable interlocked guards where motion is maintained automatically by the control system		X	X	X	X
5.1.2.4.3	Manually controlled power-operated moveable interlocked guards	X	X	X	X	X
5.2	**Specific requirements resulting from mechanical hazards**					
5.2.1	Protective measures for Group 1 machines	X	X	X		X
5.2.2	Protective measures for Group 2 machines	X	X	X		X
5.2.3	**Protective measures for Groups 3 and Group 4 machines**					
5.2.3.1	Access to the work zone	X				X
5.2.3.2	Characteristics of guards, specific requirements	X	X	X		X
5.2.4	**MO of machine operation**					
5.2.4.1	General requirements	X	X			X
5.2.4.2	Requirements for MO selection system (Group 2, Group 3 and Group 4 machines only)	X	X	X	X	X
5.2.4.3	MO 0: manual mode	X	X	X	X	X
5.2.4.4	MO 1: automatic mode	X	X	X	X	X
5.2.4.5	**MO 2: setting mode**					

[a] Only test 1 for the continuity of the bonding circuit according to IEC 60204-1:2016, 18.2, and functional test according IEC 60204-1:2016, 18.6, applies.

Table 3 *(continued)*

Clause/ sub-clause	Item	Verification method				
		Visual inspection	Functional test	Measurement	Calculation	Examination of documentation
5.2.4.5.1	Basic specifications	X	X			X
5.2.4.5.2	Range of functions	X	X	X		X
5.2.4.6	MO 3: manual intervention under restricted operating conditions	X	X	X		X
5.2.4.7	MO Service	X	X	X		X
5.2.5	**Optional or additional equipment for milling machines**					
5.2.5.1	Machines equipped with tool magazine(s)	X	X	X	X	X
5.2.5.2	Machines equipped with tool changer(s)	X	X	X	X	X
5.2.5.3	Machines equipped with workpiece handling mechanisms	X	X	X	X	X
5.2.5.4	Workpiece setting position	X	X	X		X
5.2.5.5	Additional requirements for powered workpiece clamping mechanisms	X	X	X	X	X
5.2.5.6	Clamping conditions for workpiece if turning operation is provided	X	X	X	X	X
5.2.5.7	Machines equipped with swarf/chip collection/removal system	X	X	X	X	X
5.2.5.8	Additional requirements for machines including pits	X	X	X		X
5.3	Specific requirements resulting from electrical hazards	X	X [a]	X	X	X

[a] Only test 1 for the continuity of the bonding circuit according to IEC 60204-1:2016, 18.2, and functional test according IEC 60204-1:2016, 18.6, applies.

Table 3 *(continued)*

Clause/ sub-clause	Item	Verification method				
		Visual inspection	Functional test	Measurement	Calculation	Examination of documentation
5.4	Specific requirements resulting from noise hazards	X	X	X		X
5.5	Specific requirements resulting from radiation hazards	X	X	X		X
5.6	**Specific requirements resulting from material or substance hazards**					
5.6.1	Combustible coolants	X	X		X	X
5.6.2	Minimum quantity lubrication (MQL)	X	X		X	X
5.6.3	Dry processing and combustible dust	X	X		X	X
5.6.4	Requirements for biological or microbiological 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, over-run or over-speed hazards**					
5.8.1	General	X	X			X
5.8.2	Starting	X	X			X
5.8.3	Stopping	X	X	X		X
5.8.4	Emergency Stop	X	X	X		X
5.8.5	Manual reset function	X	X			X
5.8.6	SRP/CS		X			X
5.8.7	Speed monitoring		X	X	X	X
5.8.8	Electromagnetic compatibility			X	X	X
5.9	Specific requirements resulting from failure of any power supply		X			
5.10	Specific requirements from errors of fitting hazards	X	X			
5.11	**Specific requirements resulting from ejected fluids or objects hazards**					

[a] Only test 1 for the continuity of the bonding circuit according to IEC 60204-1:2016, 18.2, and functional test according IEC 60204-1:2016, 18.6, applies.

Table 3 *(continued)*

Clause/ sub-clause	Item	Verification method				
		Visual inspection	Functional test	Measurement	Calculation	Examination of documentation
5.11.1	General requirements	X	X	X	X	X
5.11.2	Guards for Group 3 and Group 4 machines	X	X			X
5.12	Specific requirements resulting from loss of stability hazards	X	X		X	X
5.13	Specific requirements resulting from slips, trips and fall of persons hazards	X	X			X
5.14	Requirements resulting from accessibility for maintenance or trouble shooting on high parts of the machine	X				X
5.15	**Requirements for machinery with operator cabins and perimeter fencing**					
5.15.1	General	X		X		
5.15.2	Overall concept of entering/ leaving machinery	X				X
5.15.3	Requirements for movable/adjustable operator cabins/platforms	X	X	X		X
5.15.4	Requirements for perimeter fencing	X	X			X
5.16	Requirements for teleservice		X			X
6	**Information for use**					
6.1	General	X				X
6.2	Marking	X				X
6.3	**Instruction for use**					
6.3.1	General	X				X
6.3.2	Tooling	X				X
6.3.3	Workpiece clamping	X				X

[a] Only test 1 for the continuity of the bonding circuit according to IEC 60204-1:2016, 18.2, and functional test according IEC 60204-1:2016, 18.6, applies.

Table 3 *(continued)*

Clause/ sub-clause	Item	Verification method				
		Visual inspection	Functional test	Measurement	Calculation	Examination of documentation
6.3.4	Machine functions accessible from the NC panel	X				X
6.3.5	Restart	X				X
6.3.6	Noise	X				X
6.3.7	Residual risks to be addressed by the machinery user	X				X
6.3.8	Installation instructions for the machines	X				X
6.3.9	Cleaning instruction for the machine	X				X
6.3.10	Machinery with operator cabins and/or perimeter fencing	X				X

[a] Only test 1 for the continuity of the bonding circuit according to IEC 60204-1:2016, 18.2, and functional test according IEC 60204-1:2016, 18.6, applies.

6 Information for use

6.1 General

Information for use shall be provided in accordance with ISO 12100:2010, 6.4.

6.2 Marking

6.2.1 General markings

Machines shall bear markings in a distinct and permanent manner in accordance with ISO 12100:2010, 6.4. At least the following markings shall be provided:

a) for its unambiguous identification:

   1) the business name and full address of the manufacturer or the authorized representative;

   2) designation of the machinery and designation of series or type;

   3) the serial and/or machine number, if any;

   4) the year in which the manufacturing process is completed;

b) in order to indicate its compliance with mandatory requirements, i.e. the mandatory marking;

   NOTE The mandatory marking for Europe is the CE marking.

c) for its safe use:

1) the maximum permissible spindle speed of the spindle(s), in revolutions per minute;

2) ejection chute of the chip conveyor shall be marked as follows:

i) place warning labels (graphical symbols are preferable) according to ISO 7010-P015 at each visible side of the funnel; and

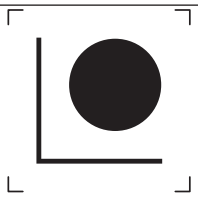
ii) a warning sign yellow-black surrounding the funnel;

3) one or several warning signs shall be visibly fixed at the machine pointing out to hazards due to gravity-loaded axes and suspended loads, for example, “Do not stay underneath the vertical axis!” (see also Annex G).

6.2.2 Symbols of operating modes (MO) on machines

For identification of the mode of operation (MO), the letter code (e.g. MO 0 or manual mode) or the following standardized symbols shall be used on the command devices and if necessary, on the HMI or the mode selection device:

Table 4 — Symbols for displaying modes of operation on machines

Mode of operation	ISO 369/ISO 7000 reference no.	Symbol	Meaning
MO 0 Manual	ISO 369-5.1–13 ISO 7000-0096		Manual control
MO 1 Automatic	ISO 369-5.1–15 ISO 7000-0017		Automatic control (closed loop)
MO 2 Setting	ISO 369-5.1–12 ISO 7000-0910		Setting
MO 3 Manual intervention under restricted operating conditions	ISO 7000-1942		Test run
MO Service Service mode	ISO 369-5.1–44 ISO 7000-0717		Call for maintenance

6.3 Instruction for use

6.3.1 General

An instruction handbook in accordance with ISO 12100:2010, 6.4.5, completed with the specific information for the stated 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 machine is suited. For all modes of operation, detailed descriptions for the intended use of these modes of operation shall be defined:

   1) information about reasonably foreseeable misuse;

   2) possible residual risks, e.g. through any provided mode of operation;

   3) the necessary qualification of operators in MO 1, in particular if the machine provides the mode of operation MO 2, MO 3 which, for example, requires experience in:

      i) adjusting and clamping of workpieces and devices;

      ii) setting, operating and monitoring of machining centres, milling machines and transfer machines;

      iii) selection, use and mounting of tools;

      iv) data input for the machining of workpieces and optimization of the machining process;

      v) specific hazards and required protective measures;

      vi) use of personal protective equipment (PPE)

   4) if the machine provides MO Service in accordance with 5.2.4.7, the manufacturer of the machine shall additionally specify:

      i) the details of the application(s) of service mode;

      ii) the required skills and the skill level for the operator(s) to operate service mode;

      iii) the following safety instructions in the instructions for use:

         — Before selecting MO Service, a chain or barrier with warning sign shall be set up to prevent unintended access to the machine. The warning sign indicates that service operations are being conducted on the machine and that unauthorized persons are not permitted to pass beyond the point of the chain or barrier;

         — instructions for use need to give clear indication about the kind and setup of the chains or barriers to be used;

b) a notice that unauthorized access to the mode selection system shall be prevented;

c) a declaration that the safeguards shall be in place and functional before initiating movements for each mode of operation;

d) a requirement for installation (if relevant, also recommendations on means to prevent access to chip discharge area); For machines using combustible coolants, which are equipped with pressure-

releasing devices, these also include information on the installation site (keeping the area above the pressure releasing device free);

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

f) instructions for any test or examination necessary after change of component parts or addition of optional equipment (both hardware and software) to Group 1 and Group 2 machines, which can affect the safety functions;

g) specification for changing safety relevant parts of control system with T10d according to ISO 13849-1:2015 less than 20 years. When using Category 3 architectures according ISO 13849-1:2015 for electromechanical components, the mechanical service life (switching cycles) for the mission time calculation is sufficient for the replacement interval;

h) the frequency of visual inspections by the user that are necessary to ensure the protective function of viewing panels, including the details of:

   1) inspection methods and a description of defects which make the viewing panel unsuitable for continued use or indicate that replacement is required. This information may include descriptions of unacceptable viewing panel condition, e.g. plastic deformation (bulges, dents) due to previous impact events, cracks, damage to edge sealing, coolant penetration into composite making the viewing panel dull or discoloured or other damage to viewing panels. Polycarbonate viewing panels are dangerous as soon as they are tarnished or discoloured, and they shall be replaced with new viewing panels before that happens;

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

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

   4) an indication that when changing viewing panels, the assembly instructions of the machine manufacturer shall be followed;

   NOTE For h), a checklist can be provided which includes specifications about assessment and the foreseen use of the viewing panel.

i) information defining the limits for the spatial envelope and maximum mass of the workpiece and workholding fixture(s);

j) 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. Lifting equipment may be required for parts over 10 kg in weight (see EN 1005-2);

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

l) recommendations on selection, preparation, application and maintenance of cutting fluids and precautions against their degradation;

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

n) recommendations on reducing fire- and explosion hazards when choosing combustible coolants. This includes, for example, information on viscosity and flashpoint as well as reduction of aerosol and vapour formation by choosing low-emission coolants (see Annex E and Annex F);

o) recommendations on additional protective measures when using combustible coolants. This includes information on:

   1) emission of hot gases at door gaps and openings of the machine;

   2) hot surfaces and perhaps live parts after a fire;

   3) restrike hazard while opening/restarting the machine immediately after a fire; and

   4) preventing ingress of foreign matter in order to preserve the safety-relevant properties of the coolant throughout its service life with regard to fire and explosion hazards, such as:

      i) cleaning agents and care products for machinery;

      ii) cleaning agents and solvents for workpieces;

      ii) foreign oils, etc.

p) if necessary, the instructions to enable the release of trapped persons;

q) recommendation concerning the use of personal protective equipment (e.g. hand, ear and eye protection, etc.); warning of the hazards arising from sharp tools/components and of the need to wear appropriate personal protective equipment;

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

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

t) 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;

u) instructions on control systems including circuit diagrams for electrical, hydraulic, and pneumatic systems;

v) in particular for Group 1 machines (manually operated machines) (e.g. manual feed and workpiece load/unload), instructions and guidance shall be provided concerning the safe methods of workpiece holding. This information shall make reference to correct use of suitable clamping devices and the use of suitable milling fixtures;

w) information for transportation of machine at least including lifting points, lifting equipment and lifting mass shall be provided.

6.3.2 Tooling

a) Information for tool selection, fitting and/or changing 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.

d) In order to prevent falls or ejections, tools shall be securely held within the holders of the magazine. For whole body access, information about residual danger due to presence of persons shall be provided in the documentation.

e) In case of high-speed cutting, information that milling tools shall be in accordance to ISO 15641:2001 and selected speed shall be less or equal of the maximum permissible tool speed (RPM).

6.3.3 Workpiece clamping

The following information about workpiece clamping and workpiece clamping devices and changeable 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, measuring clamping forces).

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

c) Information about the interface (mechanic, pneumatic, electric, etc.) shall be given.

d) The operator shall be warned that workpieces or parts of it could be hot after the machining process.

e) 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 forces, moments and spindle speeds or the efficiency of these devices;

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

   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;

   4) For magnetically operated workpiece clamping mechanism: the intervals for confirmation that the clamping force continuous to meet the application's requirements.

6.3.4 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.

6.3.5 Restart

Information shall be provided on restart procedures.

6.3.6 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 shall be indicated;

b) 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 machines (see K.3), instead of the A-weighted sound power level, the A-weighted emission sound pressure levels at points equally spaced on a path around the machine at 1 m from the machine surface and 1,6 m above the floor or platform may be declared.

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 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 4871:1996:

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

K = 2,5 dB when using ISO 3744:2010 or ISO 11204 (grade 2).

EXAMPLE For a sound power level LWA = 83 dB(A) (measured value), uncertainty *K* = 4 dB(A) for measurements made in accordance with ISO 3746. Another example for 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 machining centres and milling machines according to the definition given in 3.4.

The noise declaration shall be accompanied by the following statement:

"The noise emission values given are not exposure levels. While there is a correlation between the emission and exposure levels, emission values cannot be used to reliably determine whether or not further precautions are required. Factors that influence the actual level of exposure of the workforce include the actual work process, the characteristics of the work room and the other sources of noise, etc., 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, should enable the user of the machine to make a better risk assessment."

Information on noise emission shall also be provided in the sales literature when performance data of the machine are provided.

6.3.7 Residual risks to be addressed to the machinery user

Information shall be provided stating that guards supplied with the machine minimize the risks of ejection only in combination with all other measures described in the instruction for use.

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

Information shall be provided to the user for the utilization of appropriate inert gas or dry powder in the extinguishing system if it is foreseeable that machining leads to the existence of combustible dust, e.g. machining of aluminium, titanium or magnesium.

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 (see also 6.3.1).

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 counterbalance or machine at reduced speeds.

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

If the machine provides MO 3 and/or MO Service in accordance with 5.2.4.6 and 5.2.4.7 the manufacturer of the machine shall specify:

— the details of the application(s) of these modes of operation;

— the required skills and the skill level for the operator(s) to operate these modes of operation; and

— the operator shall be warned that swarf/chips and workpieces can be hot after processing. Furthermore, warning against cutting and stabbing hazards shall be made because swarf/chips can be sharp edged.

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

— tool selection;

— work/tool clamping; and

— maintenance.

If the machine is foreseen to be operated unattended for some or all the operating cycle, information shall be provided on how to leave the control station of the machine and how to return to it.

6.3.8 Installations instructions of machinery

Information about the foundation design, pits, bolting 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.

Information for connecting pipes and other media interfaces to the machine shall be given.

Information on how to complete protection against electric shock due to indirect contact in the machine shall be provided, e.g. by a device for automatic disconnection of the power supply to be installed by the user in the line powering the machine (RCD).

Information on how to provide protection against short circuits of the feeder circuit as far as relevant shall be provided.

6.3.9 Cleaning instructions of machinery

Information about the foreseen cleaning procedures shall be provided. Information shall be provided, that cleaning personnel shall be adequately trained. The elements that the cleaning personnel has to pay special attention to shall be clearly identified.

6.3.10 Machinery with operator cabins and/or perimeter fencing

The overall concept of entering and leaving the machinery as laid out in 5.15.2 shall be described in the information for use with details of how it is implemented in the machine.

The measures for leaving from/returning to the control cabin shall be described in the information for use (see 5.15.3 and Annex H).

6.3.11 Machinery equipped with gravity loaded axes or slant axes

Operating instructions shall describe measures to protect the operator from a fall-down of those axes. These instructions shall also point out to hazards due to gravity-loaded axes and suspended loads as well the required skill level of the operators (see also Annex G).

6.3.12 Machinery equipped with MO 3

The applications and work tasks for which MO 3 is provided shall be described in the clause “Intended Use” of the instructions for use.

Additional information shall be given to the user, which outline necessary organizational measures and procedures.

The required skill level of operators shall be defined [see 6.3.1, a), 3)].

6.3.13 Machinery that is telecontrol-ready

Operating instructions shall describe all necessary actions the operator has to take before telecontrol can be activated. The operator shall acknowledge that:

— the machine is operated in MO1 with all safeguards in place and functional;

— presence of the operator by the machine during all telecontrol operation, checking also that nobody else is around the machine.

Annex A
(normative)

Impact test method for guards on machines

A.1 General

This annex defines tests for guards used on machines. This annex applies to sample of guard materials as well as to complete guards for machines.

A.2 Test method

A.2.1 Principle

This test method is based upon machines equipped with milling cutting tools driven up to the maximum speed given by Formula (A.1):

$$v_c = B \pi n, \text{ [m/s]} \quad \text{(A.1)}$$

where

B is the maximum tool diameter which can be clamped in the machine spindle in m;

n is the maximum spindle speed in sec^{-1}.

This test method may be used for all groups of machines included in this document.

A.2.2 Test equipment

A.2.2.1 Propulsion device

The propulsion device shall allow the projectile to accelerate to ±5 % of a pre-set impact speed at the test object (see also Table B.1).

A.2.2.2 Projectile

Shape, mass and dimensions of the projectile are given in Figure A.1.

Projectiles are made from steel with the following mechanical characteristics:

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

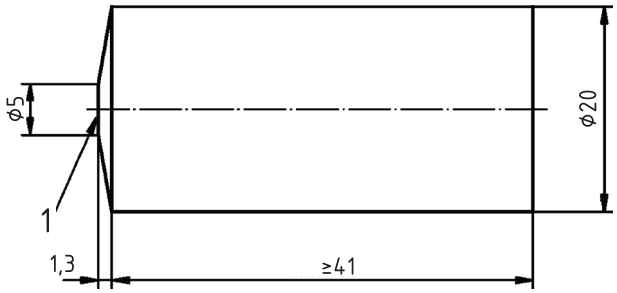
— Yield strength: $R_{0,2}$ = 330 N/mm^2;

— Elongation at rupture: A = 20 %;

— Mass: m = 0,1 kg.

As an alternative, a drop test may be performed with higher mass added to the rear of the projectile, but with 1,6 times greater impact energy (see ISO 23125:2015, A.5.2).

Dimensions in millimetres



Key

1 front view

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

Figure A.1 — Test projectile

A.2.3 Speed measurement

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.

A.2.4 Support of the test object

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

The projectile (m = 0,1 kg) speed and other values shall be calculated with Formulae (A.2) and (A.3):

— Maximum impact energy, J_c, in J: $J_c = \frac{m}{2} v_c^2$ (A.2)

— Measured impact energy, J_i, in J: $J_i = \frac{m}{2} v_i^2$ (A.3)

where

v_c is the maximum cutting speed in m/s (see A.2.1);

v_i is the measured impact speed in m/s.

The maximum impact energy shall not be less than the measured energy.

The direction of impact shall as far as possible be perpendicular to the surface. Targets for the projectile shall be the weakest and most unfavourable areas on the guard, or in the centre of the material sample and, in particular, of viewing panels.

A.3 Results

A.3.1 Damage

After the impact, any damage found on the guard or material shall be assessed and classified according to the appearance as follows:

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;

g) flying outer parts of the guard.

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) f) or g) occurs.

A.4 Test report

The test report shall give following minimum information:

— the date and place of the test and name of the test body;

— the projectile mass, dimension, speed and impact energy;

— the applicant identification;

— the design, material and dimensions of the test object;

— the clamping or fixing of the test object;

— the direction of shot, point of impact of the projectile;

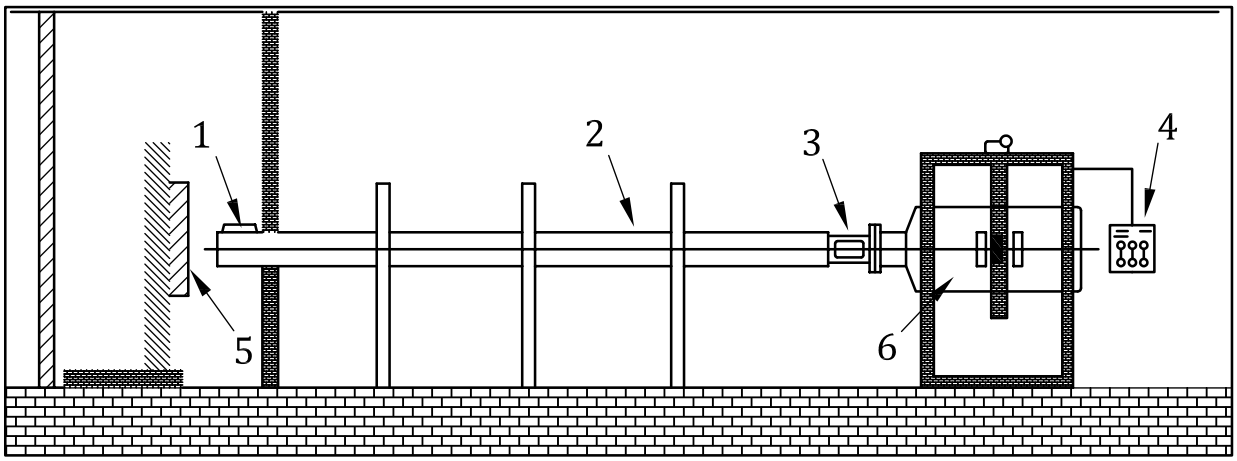
— the test result.

Annex B
(informative)

Equipment for impact test and examples of tested materials

B.1 Shooting device

The gun device consists of a compressed air vessel with flanged gun barrel (see Figure B.1). The compressed air can be released as an impulse by a special valve to accelerate the projectile towards the test object. The air is fed by an air compressor. The speed of the projectile is controlled by the pressure of the air and the volume. The projectile speed is measured near the muzzle of the gun barrel by a suitable velocimeter, e.g. by proximity sensor or photocell.



Key

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

Figure B.1 — Equipment for impact test

B.2 Examples of materials

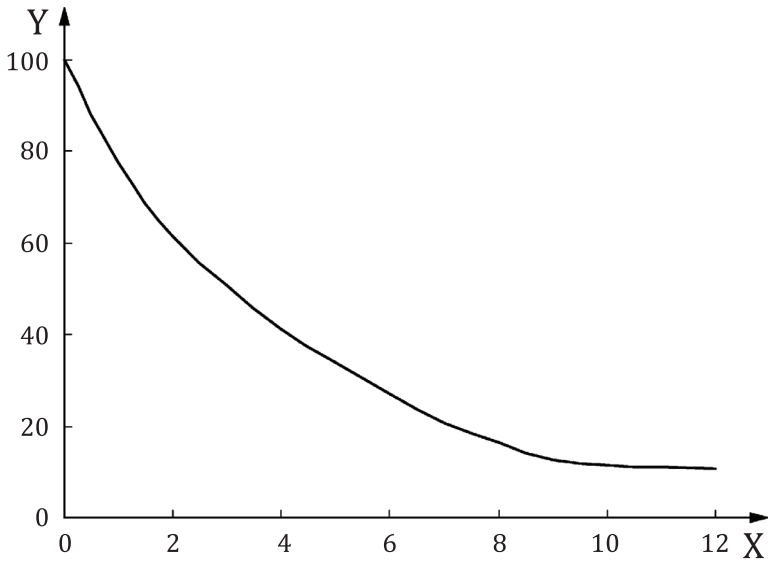
Table B.1 — Impact test results for tested material samples (m = 0,1 kg)

Material	Thickness d mm	Tensile strength R_m N/mm²	Elongation at rupture ε_B %	Velocity v_c m/s	Energy E J
St 12.03	1,5	369	28	80	320
	3,0	405	28	115	661
	1,5 + 3,0[a]	369/405	28	150	1 125
	3,0 + 1,5[a]	405/369	28	140	980
$AlMg_3$	5,0	242	18	120	720
	10,0	242	18	150	1 125
Polycarbonate[b]	6,0	68	80	100	500
	8,0			120	720
	12,0			150	1 125
	2 × 6,0			170	1 445
	2 × 12,0			230	2 645

[a] On the work zone side.

[b] Test results apply to new material without considering ageing.

Source: BIA, Saint Augustine, Federal Republic of Germany; IWF TU Berlin, Federal Republic of Germany.



Key

X time of use, expressed in years

Y impact resistance, expressed as a percentage

Figure B.2 — Ageing curve of unprotected polycarbonate (averaged test points)

Annex C
(informative)

Illustrative figures as examples of machines

C.1 Group 1 machines

See Figures C.1 and C.2.

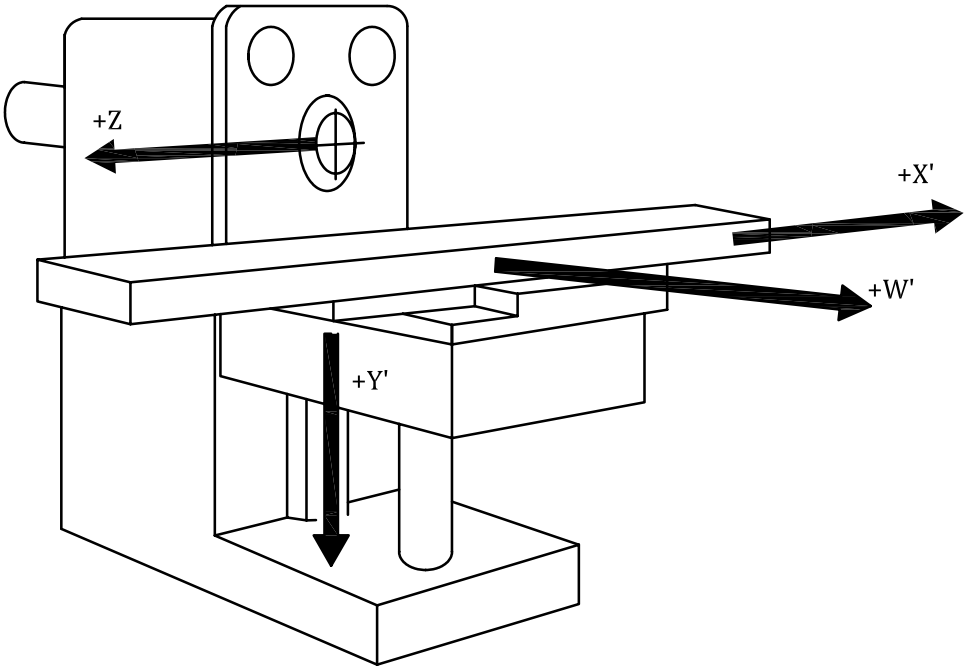


Figure C.1 — Example of a horizontal knee-type milling machine

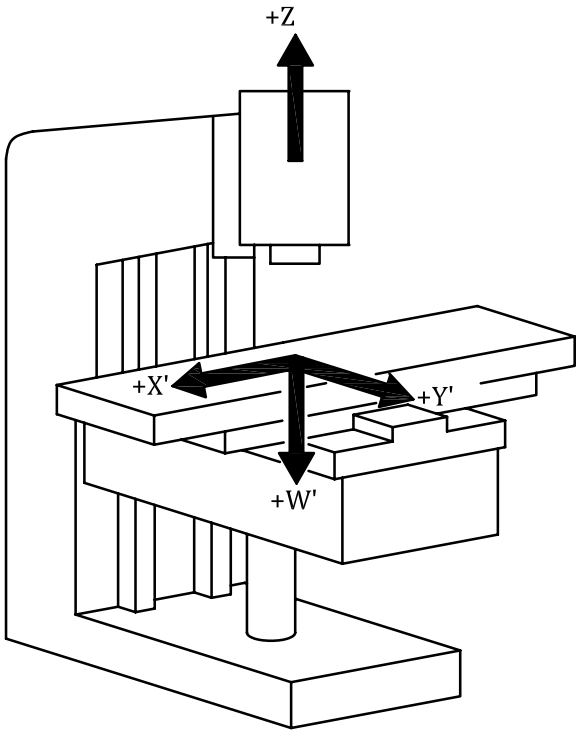


Figure C.2 — Example of a vertical knee-type machine

C.2 Group 2 machines

See Figures C.3 and C.4.

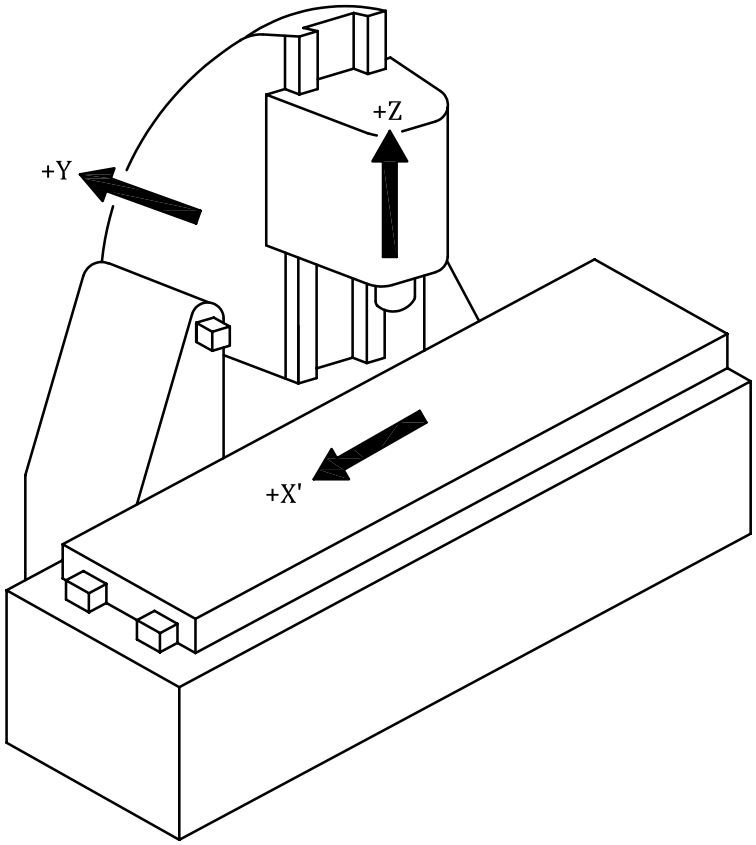


Figure C.3 — Example of a single column bed-type milling machine with vertical spindle

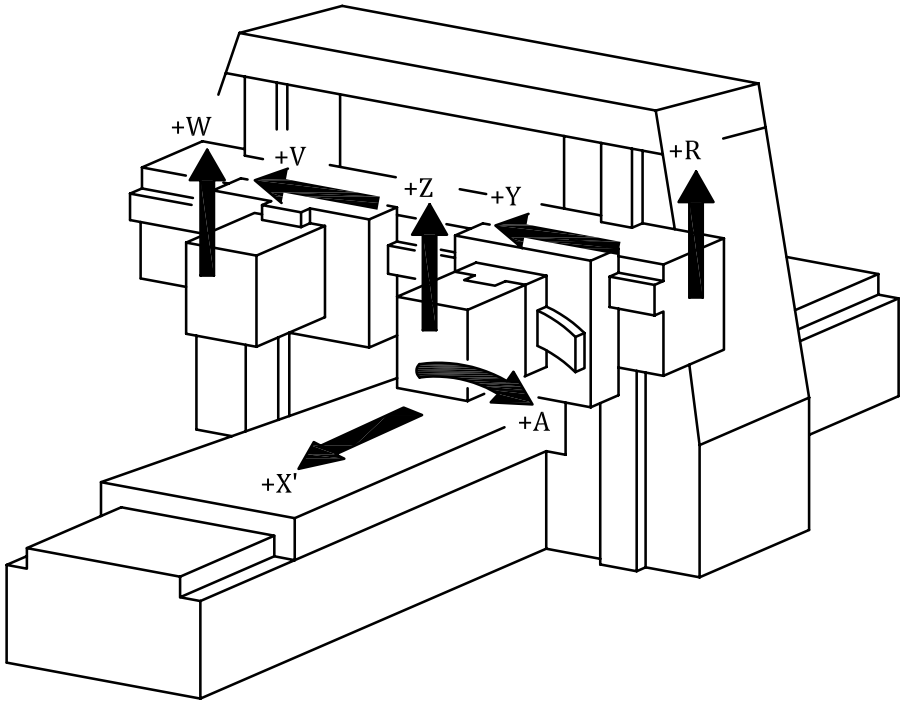


Figure C.4 — Example of a double column bed-type milling machine (portal milling machine)

C.3 Group 3 machines

See Figures C.5, C.6 and C.7.

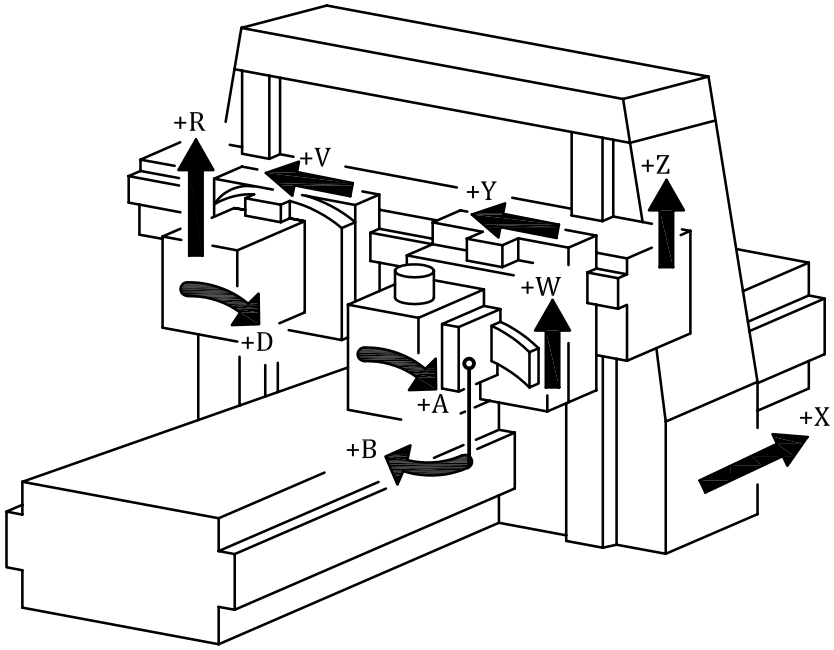


Figure C.5 — Example of a double column bed-type milling machine with moveable portal (gantry milling machine)

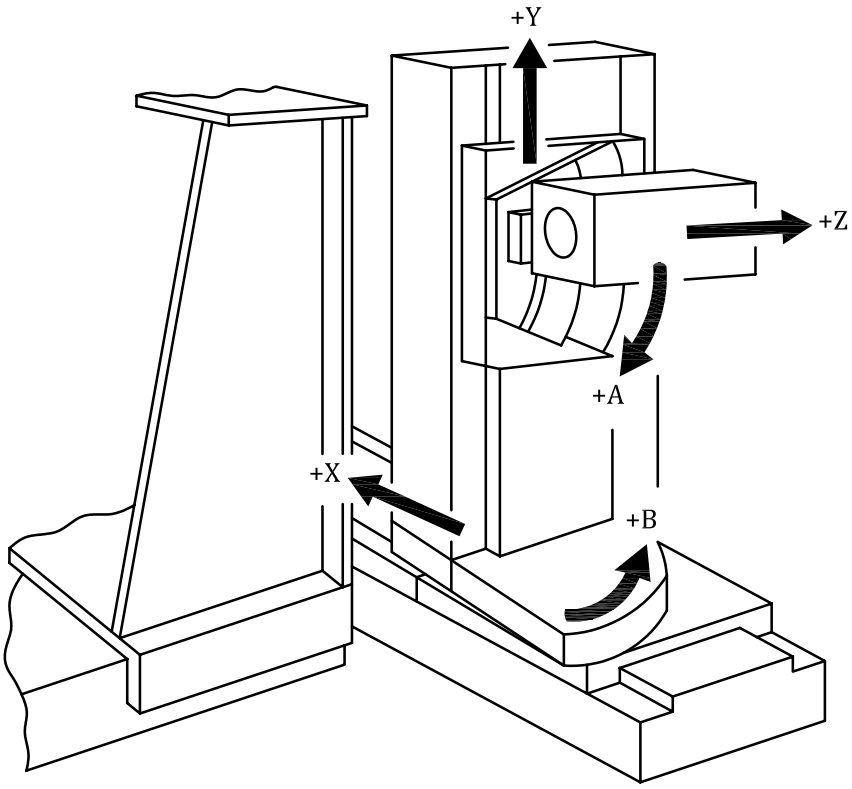


Figure C.6 — Example of a horizontal boring and milling machine

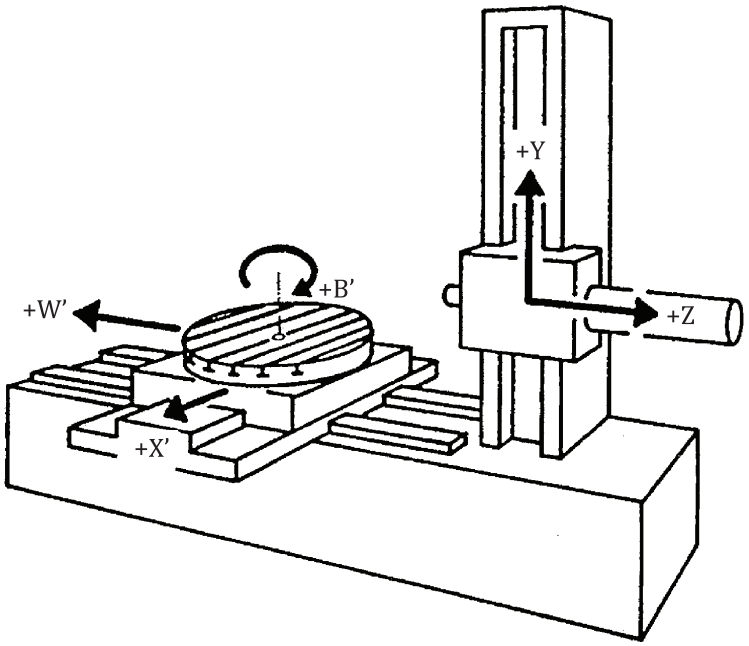
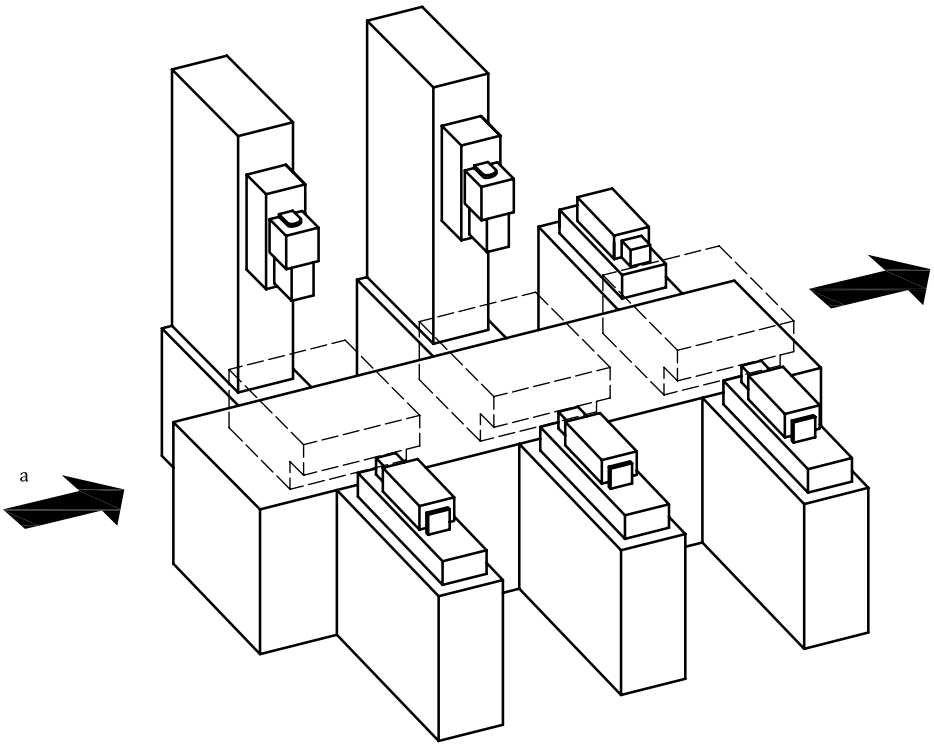


Figure C.7 — Example of a horizontal boring and milling machine

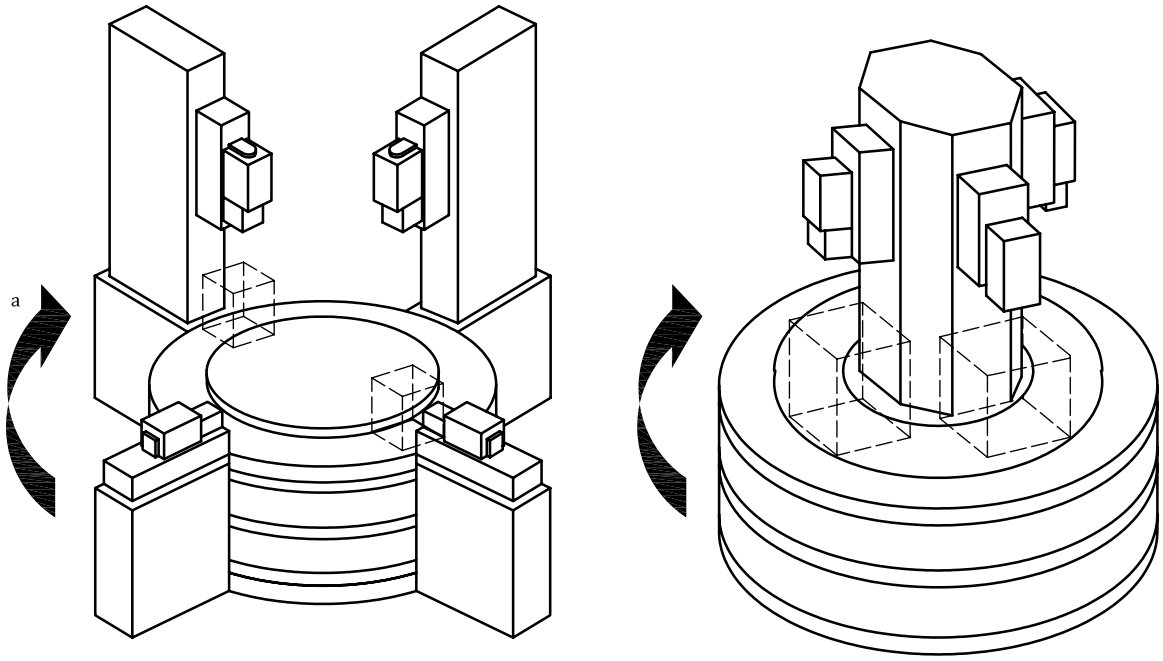
C.4 Group 4 machines

See Figures C.8 to C.13.



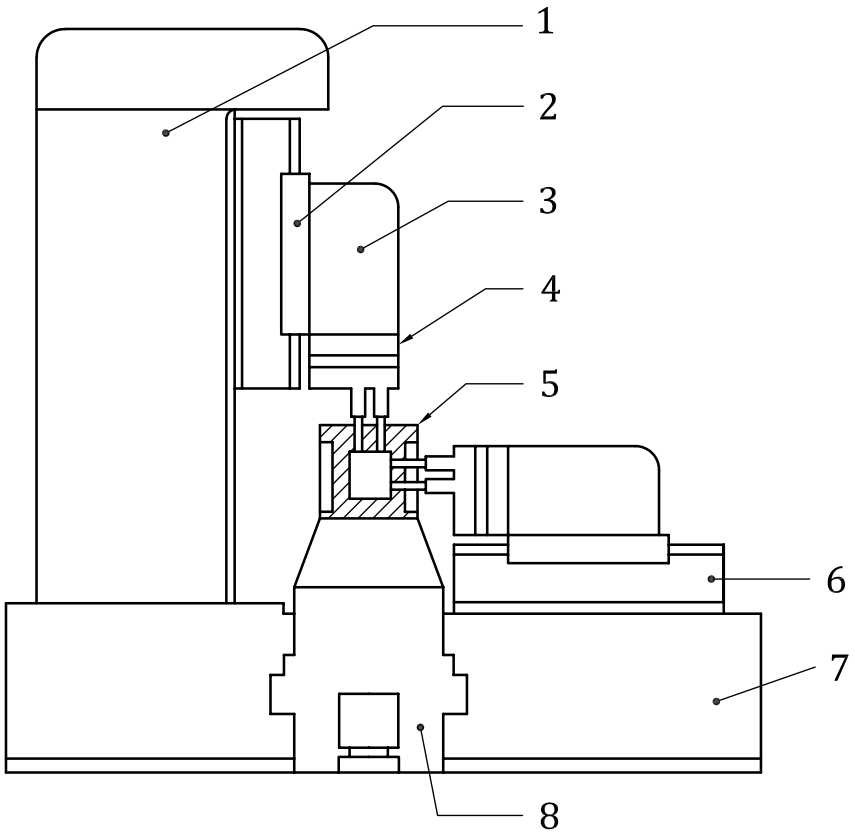
[a] Traverse direction of the workpiece.

Figure C.8 — Transfer line (illustrated without guard)



a Traverse direction of the workpiece.

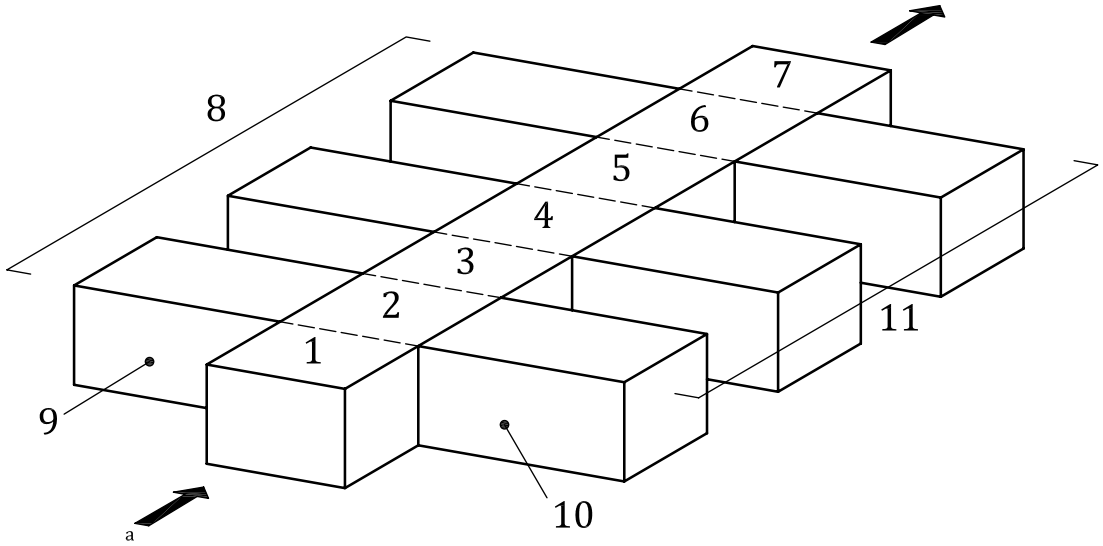
Figure C.9 — Rotary transfer machine (illustrated without guard)



Key

1	column	5	workpiece clamping device
2	slide unit	6	slide unit
3	carrier unit	7	side unit
4	multiple spindle head	8	middle unit

Figure C.10 — Side view of a processing unit of a transfer machine



Key

1 loading unit
2 processing unit
3 idle station
4 processing unit
5 idle station
6 measuring unit
7 unloading station
8 side “B” or “left hand” (LH)
9 station “02B” or “02LH”
10 station “02B” or “02RH”
11 side “A” or “right hand” (RH)
a Workpiece traverse direction.

Figure C.11 — Substructure of a transfer machine

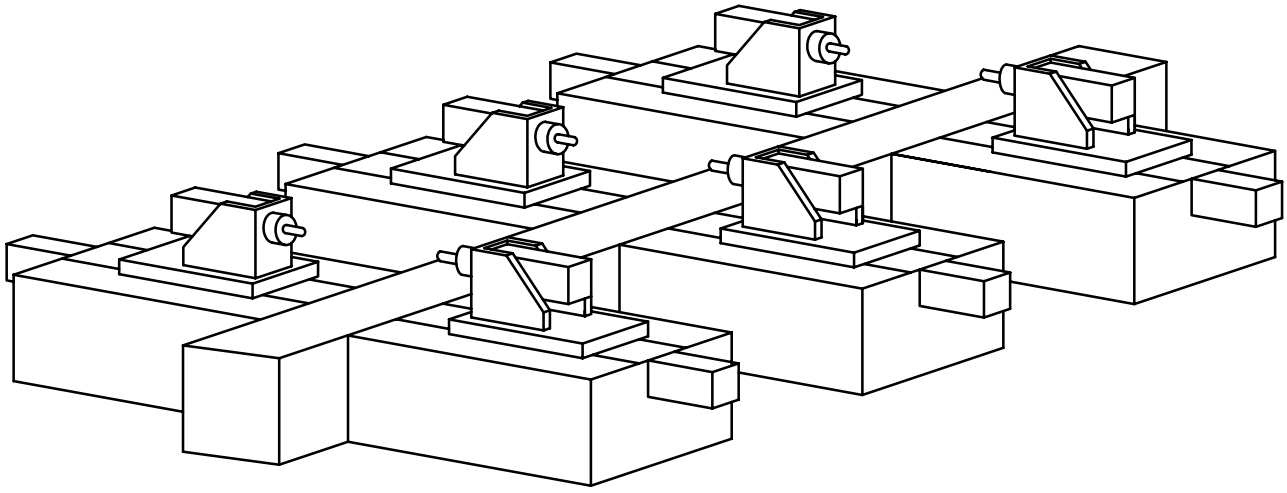
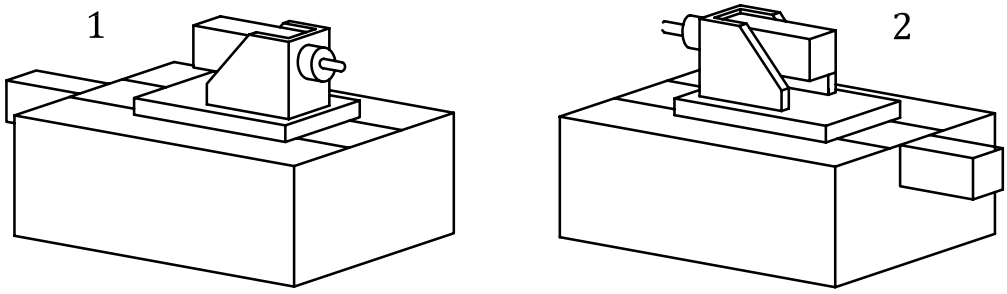


Figure C.12 — Transfer line with three processing units (illustrated without transfer device and guard)



Key

1 left unit

2 right unit

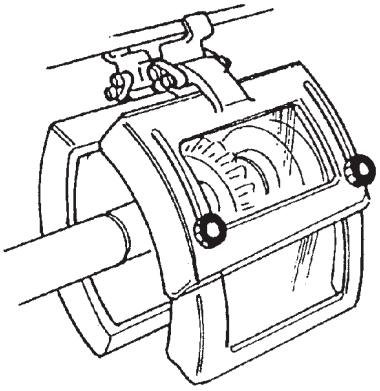
Figure C.13 — Typical units for transfer machines

Annex D
(informative)

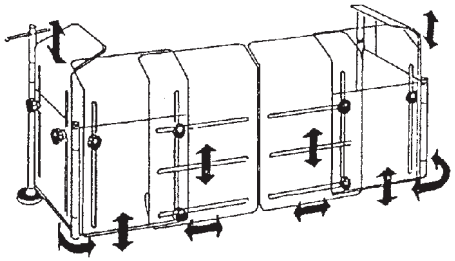
Illustrative figures as examples of guards

D.1 Examples of adjustable guards for milling machined.es; Group 1 (manual machines)

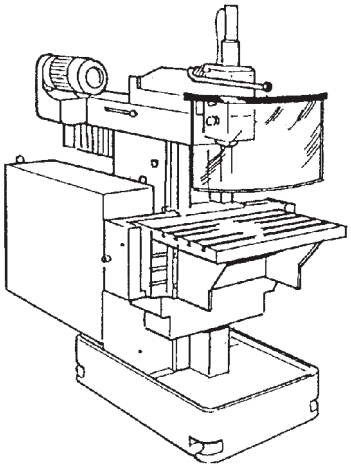
See Figure D.1.



a) Guard for horizontal milling machine



b) Guard to enclose a hazard zone

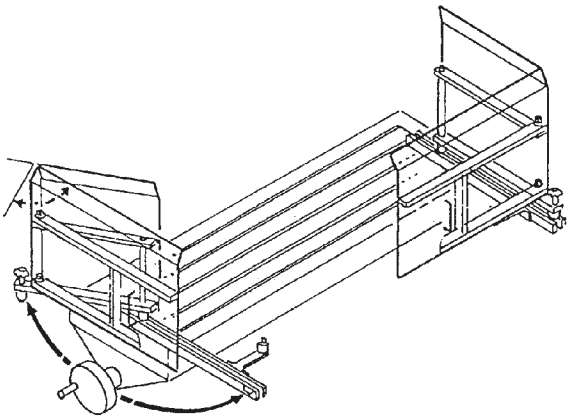


c) Guard for vertical milling machine

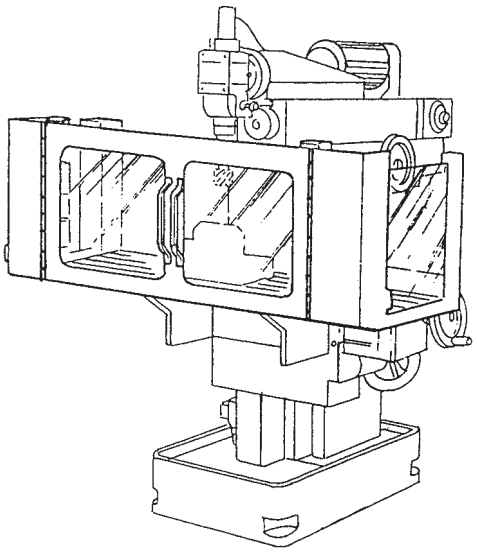
Figure D.1 — Examples of adjustable guards for manually controlled milling machines

D.2 Examples of guards for Group 2 machines (machines with limited NC capability)

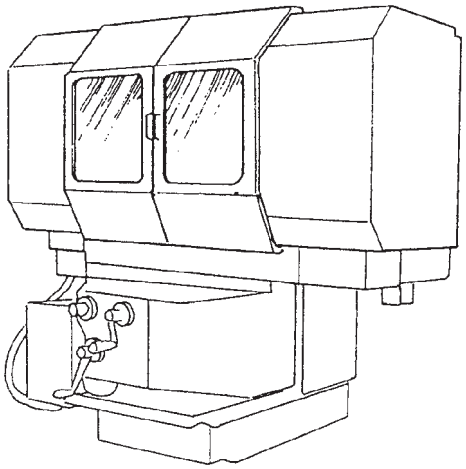
See Figure D.2.



a) Fully opening hinged guards
(NOTE Rear guard not shown)



b) Hinged door type guard

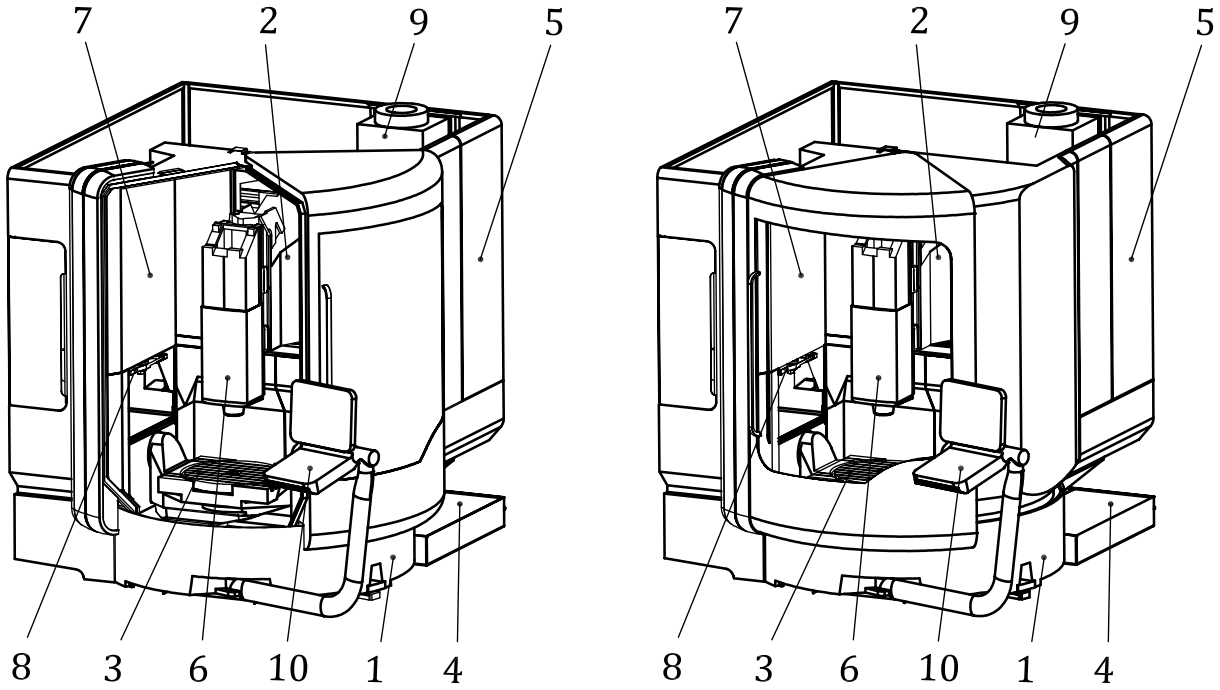


c) Sliding of guards for Group 2 milling machines

Figure D.2 — Examples of guards for Group 2 milling machines

D.3 Examples of guards for Group 3 machines (automatic machines)

See Figure D.3 to D.6.

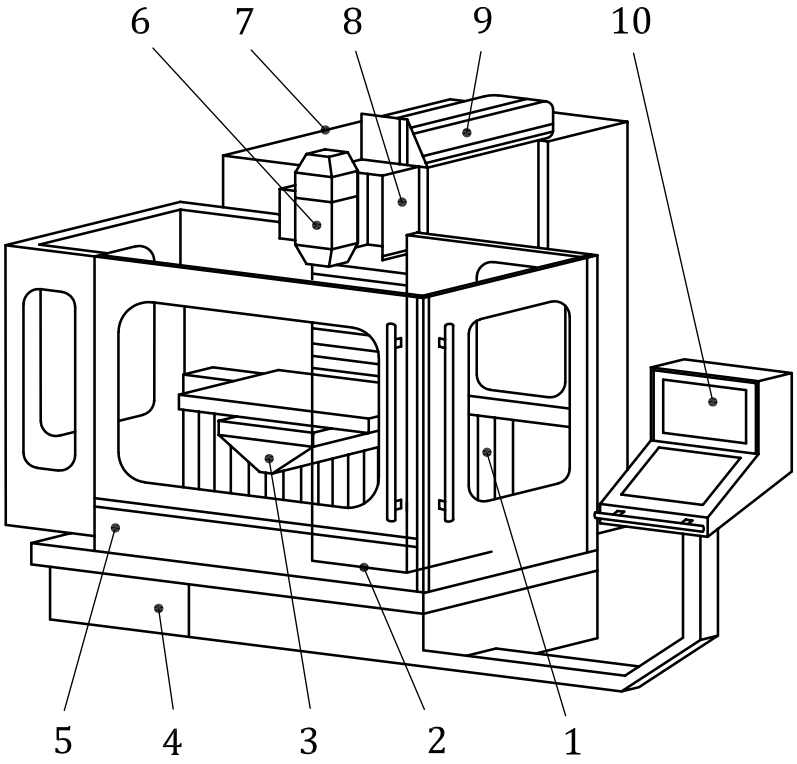


a) Guard open **b) Guard closed**

Key

1 machine column (y-axis)
2 Y slide X slide (x-axis)
3 slewing rotary table (SRT)/rigid table
4 cutting fluid system
5 machine enclosure
6 spindle head with motor spindle (Z axis)
7 electrical cubicle
8 tool change
9 cooling unit
10 control panel

Figure D.3 — Examples of guards for Group 3 machines (automatic machines)



Key

1 machine column and feed drive, y-axis
2 cross slide with vertical table and feed drive, x-axis
3 worktable; rigid table or rotary table
4 cutting fluid system
5 machine enclosure
6 milling head with vertical spindle
7 electrical cubicle
8 spindle head with horizontal spindle and feed drive, Z axis
9 main drive
10 NC panel

Figure D.4 — Example of interlocking guard(s) for automatic milling machines

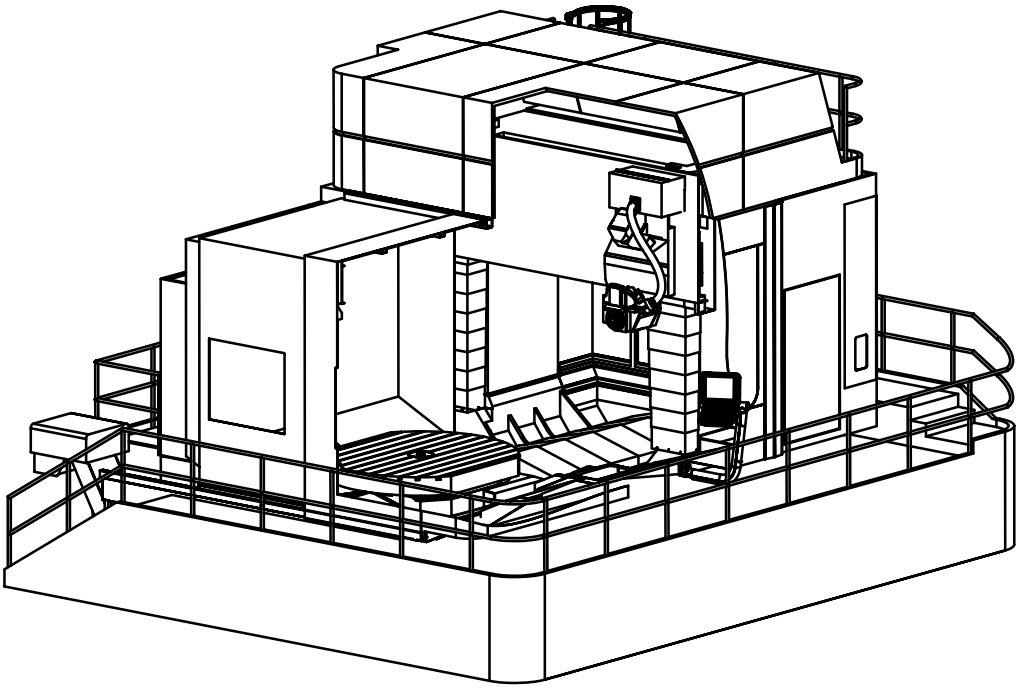
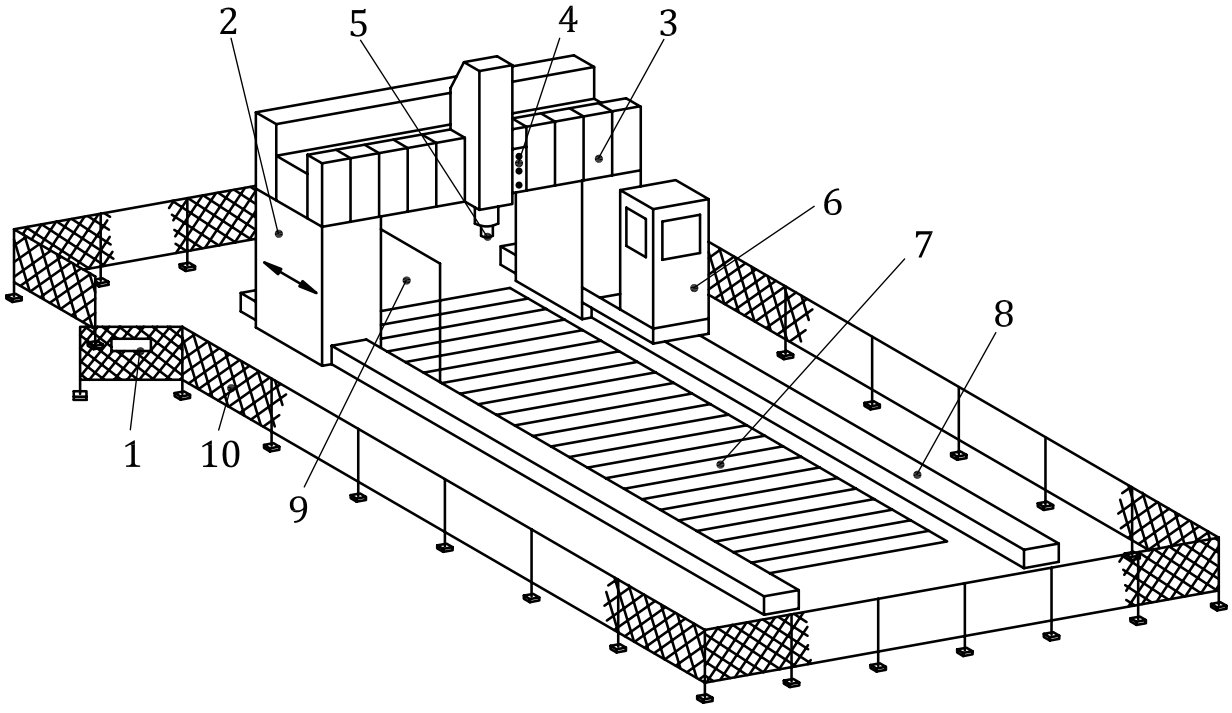


Figure D.5 — Example of a large automatic bed-type milling machine with full safe guarding of the work zone



Key

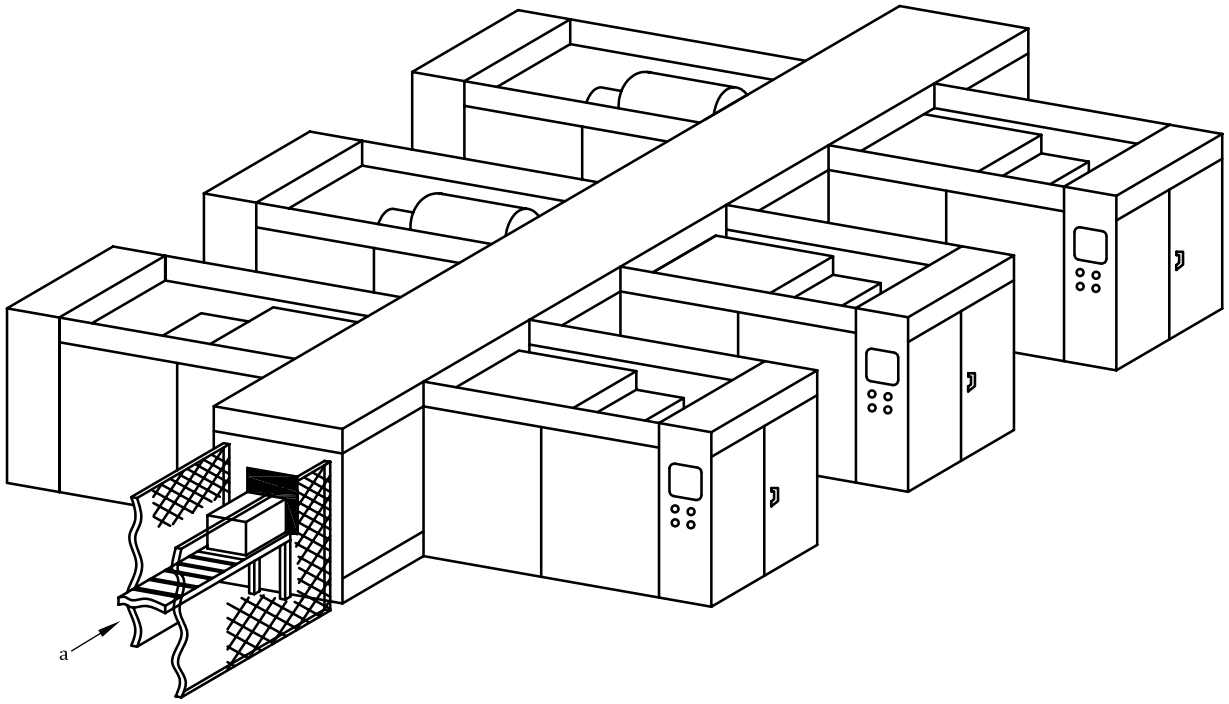
1 interlocked access
2 travelling gantry
3 telescopic steel covers
4 auxiliary pendant
5 cutter
6 cabin (operating station) enclosed on three sides; travels with gantry
7 worktable

8 slideway cover
9 blinker type guard; transparent
10 guard fence

Figure D.6 — Example of large double column milling machine with moveable portal (gantry type), perimeter fencing and operator protection

D.4 Examples of guards for Group 4 (transfer and special purpose machines)

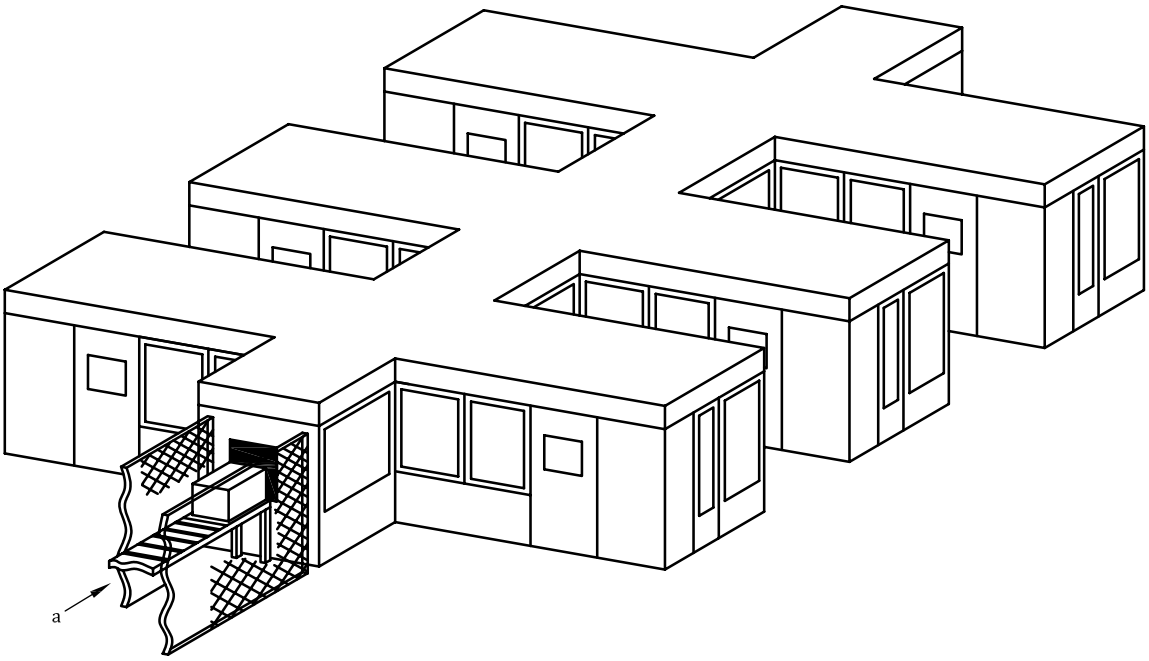
See Figure D.7 and D.8.



a Traverse direction of the workpiece.

NOTE Machines are open on top, the middle transfer unit is covered on top.

Figure D.7 — Transfer line with guards arranged closely to the machine



[a] Traverse direction of the workpiece.

Figure D.8 — Fully enclosed transfer line

Annex E
(informative)

Examples of the integration of exhaust and extinguishing systems when using combustible coolants or combustible dust

Monitoring of the coolant system and the exhaust system is essential for the safe functioning of the machine.

Protective measures after fire detection depend on the kind of exhaust system (central or local).

a) For central exhaust system with guards closed, the following shall apply:

   1) immediate stop of all machining operations (with or without controlled tool retraction);

   2) flame penetration or loss of extinguishing medium shall be suppressed by means of a closing flap (valve shutter device); although it cannot be avoided that ignition particles reach the pipes of the exhaust system;

   3) immediate initiation of the extinguishing system;

   4) deactivation of the coolant system if available and if hazards exist from mixing of combustible dust and coolant;

   5) possibility for further operation of the central exhaust system.

b) For the local exhaust system (usually on top of the machine) with guards closed, the following shall apply:

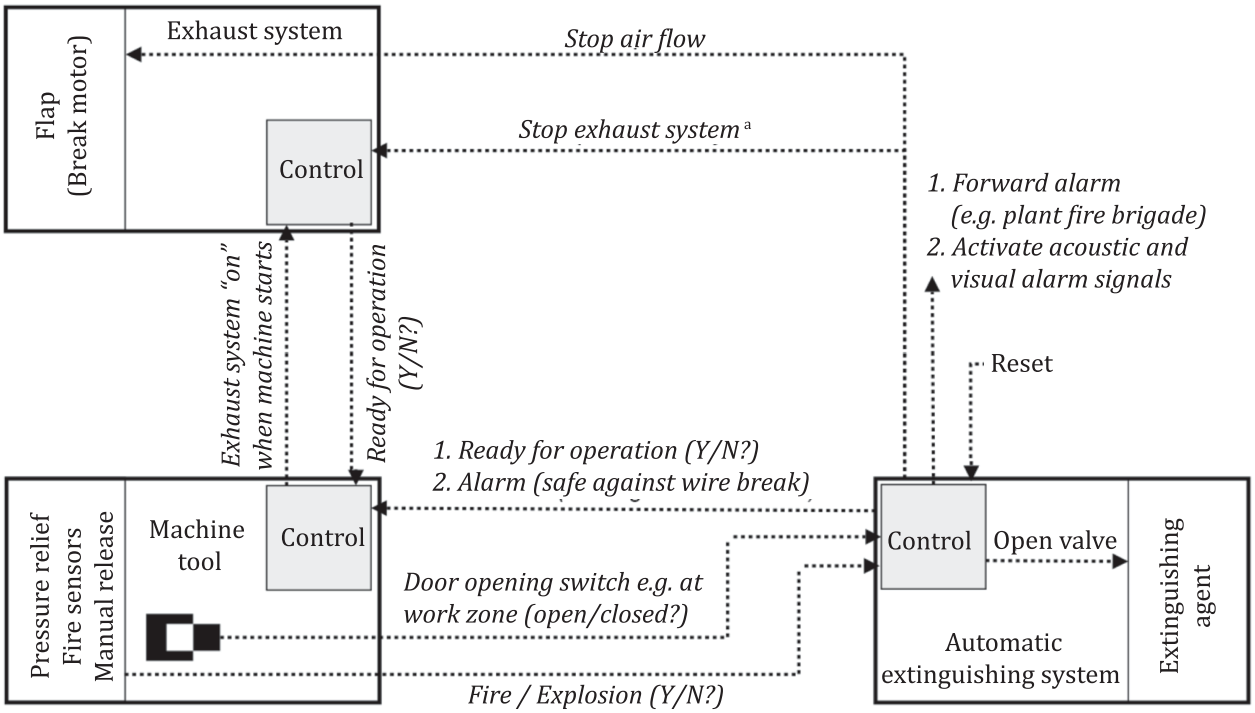
   6) immediate stop of all machining operations (with or without controlled tool retraction);

   7) deactivation of the exhaust system;

   8) immediate initiation of the extinguishing system;

   9) deactivation of the coolant supply if available and if hazards exist from mixing of combustible dust and coolant.

In order to implement the above safety functions, the controls of the machine tool, the exhaust system and the extinguishing system have suitable interfaces (see Figure E.1 and Table J.14).



[a] Only for machine mounted exhaust system.

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

Annex F
(informative)

Provisions when using combustible coolants and combustible dust

F.1 Selection of low emission coolants

Coolants with oil content above 15 % can cause fire or deflagration hazards.

By selecting non-water–miscible low-emission coolants, aerosol and vapour formation within the work zone may be reduced and thereby the risk of fire and explosion. Low-emission coolants are characterized by the following properties:

— composition based on low-evaporation mineral oils or synthetic esters and/or special fluids;

— addition of anti-mist additives.

Recommended specifications for selecting low-emission coolants depending on viscosity class and machining process are listed in Table F.1.

Table F.1 — Specification of non-water-miscible coolants

Tendency of risk	Viscosity class according to ISO 3448	Viscosity at 40 °C	Flash point according to ISO 2592 (Cleveland open cup method)	Evaporation loss at 250 °C (Noack method)	Machining process (exemplary)
High	ISO VG 5	4,14 mm^2/s to 5,06 mm^2/s	>120 °C	<85 %	honing, reaming grinding deep boring turning, milling boring tapping thread rolling broaching
	ISO VG 7	6,12 mm^2/s to 7,48 mm^2/s	>145 °C	<80 %	
	ISO VG 10	9 mm^2/s to 11 mm^2/s	>155 °C	<60 %	
	ISO VG 15	13,5 mm^2/s to 16,5 mm^2/s	>190 °C	<25 %	
	ISO VG 22	19,8 mm^2/s to 24,2 mm^2/s	>200 °C	<15 %	
	ISO VG 32	28,8 mm^2/s to 35,2 mm^2/s	>210 °C	<13 %	
Low	ISO VG 46	41,4 mm^2/s to 50,6 mm^2/s	>220 °C	<11 %	

It is generally recommended to select the coolant with the lowest evaporation loss and the highest flash point at a viscosity given by the machining process, which shall be as high as possible.

F.2 Flameproof labyrinth seals

The egress of flames into the work zone can be prevented to a great extent by application of suitable labyrinth seals on machine tool doors. Labyrinth seals with several redirections for the flame path and gap widths of ≤2 mm have proven to be most effective.

Principles of design for flameproof labyrinths:

— gaps narrowing in case of sudden pressure increase within the work zone;

— gap width at constrictions up to a maximum of 2 mm;

— change of flow direction at least 2 × 180°;

— possibility for adjusting the gap width (adjustability);

— no use of flammable materials (e.g. plastic brushes);

— direction of outlet not directly towards the operator;

— protection of shearing and crushing points by appropriate means (e.g. edge protection).

The labyrinth seal shown in Figure F.1 is based on the principle of multiple redirections arranged in series and expansion of the entering flames.

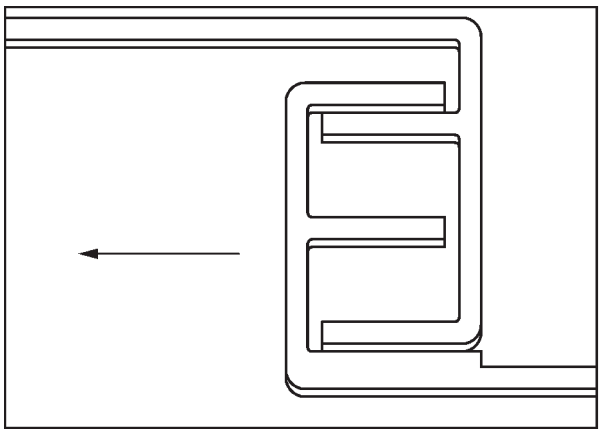
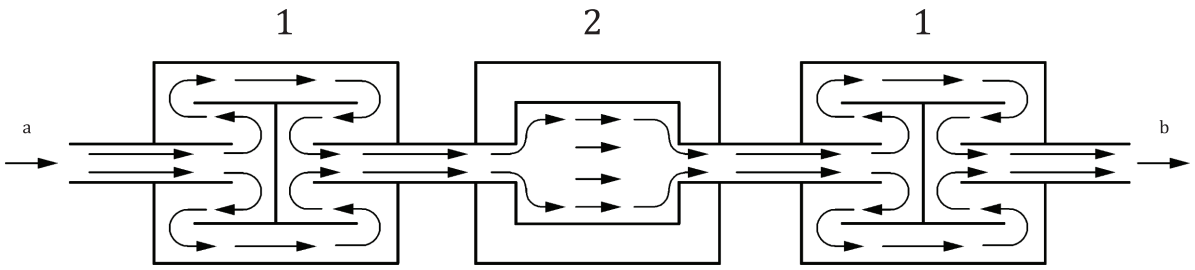


Figure F.1 — Principle scheme of a flameproof labyrinth seal

F.3 Prevention of ingress of flames into the extraction system

The use of a baffle plate in front of the extraction opening in combination with a suitable flame arrester in the extraction path may prevent flame propagation into the (central) extraction system.

The flame arrester shown in Figure F.2 is based on the principle of multiple redirection and expansion of the entering flames.



Key

1 diversion

2 expansion

[a] Air entry.

[b] Air outlet.

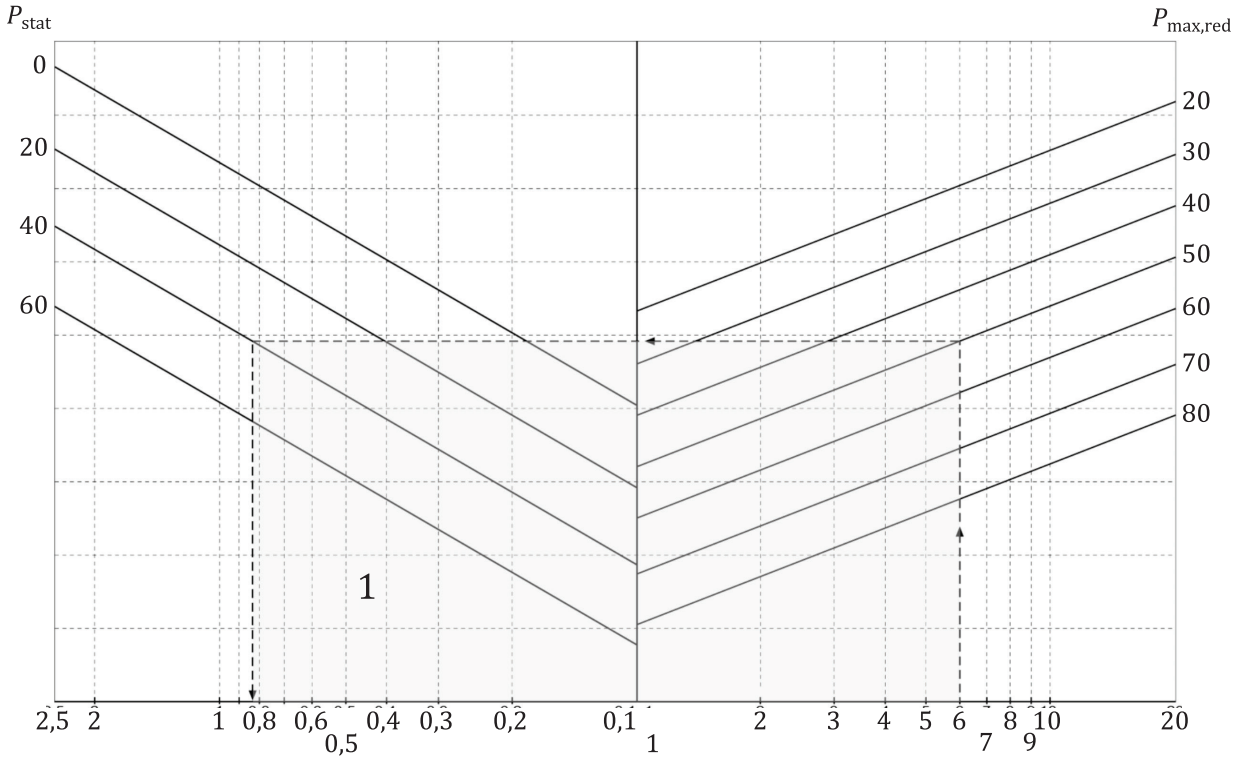
Figure F.2 — Principle scheme of a flame arrester in the extraction path

F.4 Dimensioning of pressure relief areas

Depending on the pressure resistance of the machine enclosure, the integration of a pressure relief device may be necessary to limit the explosion pressure to a non-hazardous extent and to direct escaping flames into a non-hazardous direction (e.g. pressure relief device on the machine top).

In order to determine the correct size of the pressure relief area, illustrated relations in Figure F.3 may be used. The nomogram enables the machine manufacturer, for a given enclosure volume, an estimated explosion strength of the machine enclosure and a static response pressure of the pressure relief device to determine the required pressure relief area in case it is closed with a rupture membrane. If, for example, a pressure relief flap is used, resulting from its discharge capacity in comparison to the rupture membrane is the amount by which the relief area given by the nomogram needs to be corrected. The discharge capacity is the measure for assessing the effectiveness of a pressure relief device in comparison with a rupture membrane of the same relief area. It can be determined in a test and is normally specified by the manufacturer.

A simpler (but certainly less accurate) way to determine the minimum pressure relief area on machine tools is based on the rule of thumb, after that 0,1 m^2 pressure relief area shall be provided for each m^3 of machine work zone volume. In the past, such setups were confirmed by single ignition trails. However, this rule of thumb is neither taking into account the explosion strength of the machine housing nor the response pressure of the pressure relief device.



Key

1	degree of filling
P_{stat}	static response pressure in mbar
$P_{max, red}$	maximum reduced pressure of explosion in mbar
	discharge surface in m^2
	work zone volume in m^3

Figure F.3 — Explosion relief – Nomogram for estimation of required area

Annex G
(normative)

Gravity-loaded axes

G.1 Design measures for gravity-loaded axes

In case of power failure (loosing energy), gravity-loaded axes (weight-loaded, vertical axes, inclined axes, slant axes) are held solely by the brake which is installed in the electric drive motor (motor brake) or an external brake or a clamping device. The gravity loaded axes could descent in case of failure. Mechanical wear or oil-fouling can cause the braking torque/force of the brakes to fall below its nominal value which can result in an unintended descend or the fall-down of the gravity-loaded axes.

If these gravity-loaded axes allow the operator to stay completely or partially under the axis (e.g. for loading of tools/workpieces, for setting and maintenance), measures for minimizing the risk shall be taken.

Depending on the practical case of application and the risk to be reduced, different technical safety devices are suitable to prevent the unintended gravity descent of gravity-loaded axes (see Table G.1 and G.2).

Safety functions related to gravity loaded or slant axis are defined in Table J.3.

G.2 Measures against unintended descent of gravity-loaded axes

G.2.1 General requirements

The mechanical parts of power transmission shall be at least designed with double weight load to withstand the occurring static and dynamic stresses.

In order to prevent unnecessary wear of the brakes, it is preferable to decelerate with the controller instead of stopping with mechanical brakes.

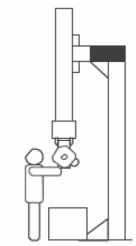
NOTE In case no hazard exists because the operator is always in safe position for gravity-load axes, a motor brake can be installed on the machine for faster braking during operations or other reasons.

G.2.2 Information for use

Warning signs shall be visibly fixed at the machine according to 6.2.1 c) 3).

Operating instructions shall be given according to 6.3.11.

Table G.1 — Assignment of common braking devices to the individual modes of operation

			Typical situations			
			Typical hazardous situations in all MO, except maintenances		Typical hazardous situations for maintenance	
No	**Design of braking device**	**Requirement for cyclic test; see also G.3**	 **G1.1** The gravity-loaded axis is located within the hazardous area. Staying under the gravity-loaded axis with the whole body is prevented by the machine design A hazard exists for the upper limbs.	 **G1.2** The gravity-loaded axis is located within the hazardous area (see 3.3.8). Staying under the gravity-loaded axis cannot be prevented.	 **G1.3** Maintenance, cleaning and repair works are carried out at or next to the gravity-loaded axis. Safe support of the gravity-loaded axis is feasible.	 **G1.4** Maintenance, cleaning and repair works are carried out at or next to the gravity-loaded axis. Safe support of the gravity-loaded axis is not feasible.
1	Single brake	mandatory	✓	✓ [c]	Support or manual mechanical lock	
2	Motor brake + redundant brake[a]	mandatory	✓	✓	Support or manual mechanical lock	
3	Brake where fault exclusion can be justified	No test, fault exclusion required	✓	✓	✓	
4	Motor brake + mechanical counterweight	mandatory	✓	✓	Support or manual mechanical lock	
5	Motor brake + hydraulic counterweight	mandatory	✓	—	Support or manual mechanical lock	

[a] Redundant brake can be internal if a fault to the single transmission system can be excluded (e.g. mechanical break of the motor shaft), otherwise, external redundant brake.

[b] For example, a hydraulic counterweight with fault exclusion to “non-returning-blocking” valves with cross monitoring (e.g. double valves).

[c] Feasible in case of a short presence (see 3.1.17) only under the gravity loaded axis.

[d] For self-locking device: cyclic test is not required, mechanical design with double weight load. Test for motor brake is required.

Table G.1 *(continued)*

			Typical situations		
			Typical hazardous situations in all MO, except maintenances		Typical hazardous situations for maintenance
6	Motor brake + counterweight[b] where fault exclusion can be justified	No test, fault exclusion of counterweight system required	✓	✓	✓
7	Motor brake + self-locking device (e.g. pinhole device) shall limit falling of the gravity loaded axis to 50 mm or less	mandatory [d]	✓	✓	✓

[a] Redundant brake can be internal if a fault to the single transmission system can be excluded (e.g. mechanical break of the motor shaft), otherwise, external redundant brake.

[b] For example, a hydraulic counterweight with fault exclusion to “non-returning-blocking” valves with cross monitoring (e.g. double valves).

[c] Feasible in case of a short presence (see 3.1.17) only under the gravity loaded axis.

[d] For self-locking device: cyclic test is not required, mechanical design with double weight load. Test for motor brake is required.

Table G.2 — Additional protective measures and instructions for use

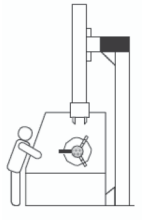
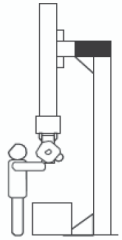
	Typical situations			
	Typical hazardous situations in all MO, except maintenances		Typical hazardous situations for maintenance	
Measures and information for use	 **G1.1** The gravity-loaded axis is located within the hazardous area. Staying under the gravity-loaded axis with the whole body is prevented by the machine design A hazard exists for the upper limbs.	 **G1.2** The gravity-loaded axis is located within the hazardous area (see 3.3.8). Staying under the gravity-loaded axis cannot be prevented.	 **G1.3** Maintenance, cleaning and repair works are carried out at or next to the gravity-loaded axis. Safe support of the gravity-loaded axis is feasible.	 **G1.4** Maintenance, cleaning and repair works are carried out at or next to the gravity-loaded axis. Safe support of the gravity-loaded axis is not feasible.
Required protective measures	—	—	— Observe the regulations in force for maintenance/repair/cleaning, e.g. lockable mains switch — Support or, as far as still possible, move to lowest end position — Disconnect and lock main switch	— Observe the regulations in force for maintenance/repair/cleaning, e.g. lockable main switch — Device to be operated automatically or manually for safe fixing of the axis in the defined positions, e.g. fixing device — Clear marking of the positions locked/unlocked — Monitoring of positions by the control locked/unlocked and interlocking with drive control — Disconnect and lock main switch

Table G.2 *(continued)*

	Typical situations			
	Typical hazardous situations in all MO, except maintenances		**Typical hazardous situations for maintenance**	
Information for use	See G.2.2	See G.2.2	See G.2.2 and — Describe measures for safe support of gravity-loaded axis — Explain how to disconnect and lock the main switch	See G.2.2 and — Describe measures for the use of the devices for safe fixing (e.g. mechanical lock) of the gravity loaded axis — Explain how to disconnect and lock the main switch — Inform on necessity to limit stay under the gravity load axis as far as possible

G.3 Cyclic test of brake or self-locking device at Group 3 and Group 4 machines

An effective measure may be a cyclic test of the single brake (brake test) or a clamping device. For this, a test torque/force is applied to the brake, e.g. motor brake or the clamping device.

This cyclic test interval shall be carried out according to Table G.3. The cyclic test shall take place automatically in the closed protective zone during normal production, e.g. during a process-related stop. If this is not possible, the cyclic test shall be carried out before entering to the hazardous zone.

For the cyclic test, it is reasonable that the gravity-loaded axes, which are to be tested, are located at defined positions, such as:

— positions on which tests (brake and/or clamping device) can be carried out without obstruction/ interfering contour (e.g. tool not active);

— positions from which fault recovery after, e.g. a fault at the brake test can be achieved or a safe position can be approached.

For test torque/force to following requirements apply:

— 1 motor/1 brake (or clamping device) system:

  The brake or the clamping device is charged with 1,3 times the maximum gravitational load for at least 1 s by the electric drive. If also a permanently present counterweight system is installed, the braking device is charge with 1,3 times the maximum gravitational weight minus the counterbalanced weight.

— 1 motor/2 brakes system:

  The braking devices are tested separately one after the other on 1,0 times the maximum gravitational load.

— 2 motors/2 brakes system, mechanically connected:

  The braking devices are tested together on 2,0 times the maximum gravitational load or one after the other on 1,0 times the maximum gravitational load.

  In case of a fault detection occurs during the cyclic test, the following requirements apply.

— The indications given by the machine control shall request for brake repair. In case of moveable interlocked guards with guard locking, a safe position shall not be approached until an unlock demand signal has been given.

— Further operation of the machine shall only be possible after a new successful cyclic test.

Table G.3 — Brake test intervals

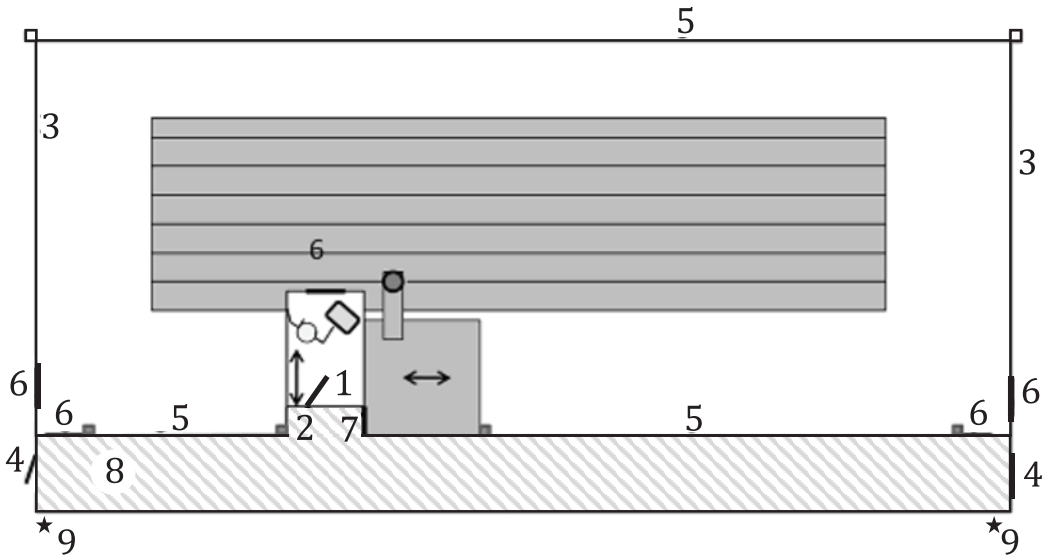
Group 3 and Group 4 machines	Brake test intervals
Machine with manual load-/unloading into the work zone	— 8 h[a,b] – once per shift automatically; or — test before access to the related hazard zone takes place (move gravity-loaded axes in safe position) and time of 8 h[b] has run out
Machines with automatic load-/unloading into the work zone	— 48 h[b]; or — test before access to the related hazard zone takes place (move gravity-loaded axes in safe position) **and** time of 48 h[b] has run out

[a] In case of a complex single workpiece (e.g. large tools for presses or turbine blades, etc.), with an expected machining time longer than 8 h, the cyclic test shall be carried out after finishing the machining of the workpiece. If the cyclic test fails, further operation of the machine shall be inhibited.

[b] In case of a redundant motor brake, the minimum test time is increased and has to be initiated every time after powering-on the machine and at least every month.

Annex H
(informative)

Examples: Concept for leaving/returning to a cabin (control station) at Group 3 and Group 4 machines



Key

1 cabin
2 cabin guard
3 fixed guard
4 interlocking movable guard with guard locking with the possibility to open from inside
5 safeguarding
6 moveable interlocked guard which leads to the work zone
7 PSPD
8 floor equipped with sensors (safe area)
9 RFID, key transfer system

Figure H.1 — Example for leaving the cabin of a large Group 3 milling machine

To leave and return to cabin (1), the movable interlocked guard (2) of the cabin can be used. Movement of the cabin can cause hazardous situations; a PSPD (7), e.g. tactile protection device should be activated. The safeguards (5) and (6) are then in a safeguarding position and activated.

To leave the cabin, only one of the two movable interlocked guards (4) should be selected and could be opened. To open the guard, a transfer function shall be manually activated, e.g. floor equipped with sensors and near the movable interlocked guard located within the interior zone which is not accessible from outside the guard (8). This causes a takeover by the interlocking device of the guard (4) for certain time (e.g. 15 s). Closing the movable interlocked guard after leaving the safe area is followed by a takeover from outside the safe area (8) which initiates the end of the takeover by the interlocking device of the guard (4). Exceeding the transfer time (e.g. 15 s) causes a warning signal followed by an emergency stop.

To return to the cabin from outside the machine a protective measure (9) for identifying a person shall be activated (e.g. RFID, key transfer system) so that the guard can be opened for a certain time (e.g. 15 s). Within this time frame, the person should have passed the movable interlocked guard (4) into the safe area (8) and close the movable interlocked guard from within the safe area. After this procedure, the person can enter the cabin while the guard of the cabin is open towards the rear (2) of the machine.

Annex I
(informative)

Typical demand rates of safety functions for calculations according to Table 3 and Annex J

Table I.1 — Provisions of typical demand rates of the safety function

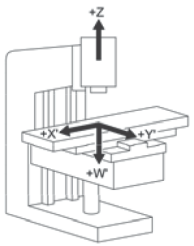
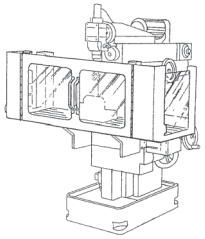
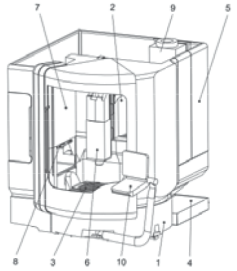
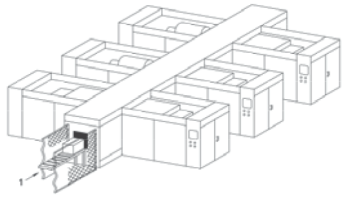
					
		Group 1	**Group 2**	**Group 3**	**Group 4**
No.	**Function**	**Number of operations**	**Number of operations**	**Number of operations**	**Number of operations**
1	Mean operating time in days per year	300	300	300	300
2	Mean operating time in hours per day	8	8	16 NOTE At automatically operated machines that are in operation 24 h a day, the security is usually just as often requested as a hand-loaded machine with an average operating time of 16 h.	24
3	Emergency stop	Once per day	4 times per day	Once per week	Once per week
4	Enabling device work zone	*Reference values not available*	Once in 6 min (360 s)	Once in 12 min (720 s)	3 times per day
5	Enabling device tool magazine	*Reference values not available*	*Reference values not available*	Once in 15 min (900 s)	Once in 15 min (900 s)
6	Enabling device Workpiece setting position	*Reference values not available*	*Reference values not available*	Once in 12 min (720 s)	Once in 12 min (720 s)
7	Tool magazine, protection door; manual tool loading	*Reference values not available*	*Reference values not available*	Once in 15 min (900 s) NOTE 16 h per day make 64 tool loading and unloading processes.	Once in 15 min (900 s) NOTE 24 h per day make 96 tool loading and unloading processes.

Table I.1 *(continued)*

8	Opening of the interlocked guard to unload/load the workpiece in the work zone. Short machining period (up to 10 min).	*Reference values not available*	*Reference values not available*	Once in 5 min (300 s)	*Reference values not available*
9	Opening of the interlocked guard to unload/load the workpiece in the work zone. Medium machining period (up to 60 min).	*Reference values not available*	*Reference values not available*	Once in 15 min (900 s) NOTE 16 h per day make 64 workpiece loading and unloading processes.	*Reference values not available*
10	Opening of the interlocked guard to unload/load the workpiece in the work zone. Long machining period (up to 8 h and more).	*Reference values not available*	*Reference values not available*	Once in 8 h NOTE 16 h per day make 2 workpiece loading and unloading processes.	*Reference values not available*
11	Protection door to workpiece setting position for loading of pallet changer, open interlocked guard, load workpiece. Short machining period (up to 10 min).	*Reference values not available*	*Reference values not available*	Once in 2 min (120 s) NOTE 16 h per day make 480 workpiece loading and unloading processes.	Once in 2 min (120 s) NOTE 24 h per day make 720 workpiece loading and unloading processes.

Table I.1 *(continued)*

12	Protection door to workpiece setting position for loading of pallet changer, open interlocked guard, load workpiece. Medium machining period (up to 60 min).	*Reference values not available*	*Reference values not available*	Once in 15 min (900 s) NOTE 16 h per day make 64 workpiece loading and unloading processes.	Once in 15 min (900 s) NOTE 24 h per day make 96 workpiece loading and unloading processes.
13	Protection door to workpiece setting position for loading of pallet changer, open interlocked guard, load workpiece. Long machining period (up to 8 h and more).	*Reference values not available*	*Reference values not available*	Once in 8 h NOTE 16 h per day make 2 workpiece loading and unloading processes.	*Reference values not available*
14	Tool clamper, number of tool changes. Short machining period (up to 10 min).	*Reference values not available*	*Reference values not available*	2 times per minute (30 s)	2 times per minute (30 s)
15	Tool clamper, number of tool changes. Medium machining period (up to 60 min).	Once per 5 min (300 s)	Once per 5 min (300 s)	Once per minute (60 s) NOTE At Automatically operated machines that are in operation 24 h a day, the safety functions are usually requested just as often as a hand-loaded machine with an average operating time of 16 h.	Once per minute (60 s)
16	Tool clamper, number of tool changes. Long machining period (up to 8 h and more).	*Reference values not available*	Once per 5 min (300 s)	Once per 10 min (600 s)	*Reference values not available*
17	Automatic tool changer	See tool clamper	See tool clamper	See tool clamper	See tool clamper

Table I.1 *(continued)*

18	Metalworking fluid. High-pressure. Short machining duration (up to 10 min).	*Reference values not available*	*Reference values not available*	Twice per minute (30 s)	2 times per minute (30 s)
19	Metalworking fluid. High-pressure. Mean machining duration (up to 60 min).	*Reference values not available*	*Reference values not available*	Once per minute (60 s)	Once per minute (60 s)
20	Metalworking fluid High-pressure. Long machining period (up to 8 h and more).	*Reference values not available*	*Reference values not available*	Once per 10 min (600 s)	*Reference values not available*
21	Workpiece clamping devices (hydraulic, pneumatic) short machining period (up to 10 min)	*Reference values not available*	Once per 5 min (300 s) NOTE 8 h per day make 96 workpiece loading and unloading processes.	Once per 2 min (120 s) NOTE 16 h per day make 480 workpiece loading and unloading processes.	Once per 2 min (120 s) NOTE 24 h per day make 720 workpiece loading and unloading processes.
22	Workpiece clamping devices (hydraulic, pneumatic) Mean machining period (up to 60 min).	*Reference values not available*	Once per hour (3 600 s) NOTE 8 h per day make 8 workpiece loading and unloading processes.	Once per 15 min (900 s) NOTE 16 h per day make 64 workpiece loading and unloading processes.	Once per 15 min (900 s) NOTE 24 h per day make 96 workpiece loading and unloading processes.
23	Workpiece clamping devices (hydraulic, pneumatic). Long machining period (up to 8 h and more).	*Reference values not available*		Once in 8 h NOTE 16 h per day make 2 workpiece loading and unloading processes.	*Reference values not available*
24	Selection of mode of operation MO 1, MO 2 or MO 3	*Reference values not available*	4 times per hour	Once per hour	Once per hour
25	Start/Stop	Once in 15 min (900 s)	Once in 15 min (900 s)	*Reference values not available*	*Reference values not available*

Annex J
(normative)

Safety functions

J.1 Index of safety functions for Tables J.1 to J.22

Table No.	Subject	Number of SF	PL_r
J.1	**Explanation on how to read the tables of safety functions**		
1.1	Requirement (mandatory)		Required PL for that requirement
J.2	**Tool spindle rotation and tool clamping device**		
2.1	Prevent start/restart function initiated by an incorrectly clamped tool in MO 1, MO 2 and MO 3	SF 03	a
2.2	Prevention of unexpected start-up of unclamping movement of the tool-gripper initiated by tool spindle speed n > 0 in MO 1, MO 2, MO 3	SF 08-1	
	in MO 1 protection by guards		b
	in MO 2 and MO 3		c
2.3	Limited spindle speed initiated by safety related tool parameter in MO 1, MO 2 and MO 3	SF 16	a
2.4	Limited spindle speed initiated by safety related parameter in MO 2 and MO 3	SF 16	See Table J.17, 17.3 and 17.4
J.3	**Gravity-loaded or slant axes**		
3.1	Safety-related stop function in MO 1, MO 2 or MO 3 (opening interlocked guards)	SF 01	
	If work zone is not accessible at all		None
	Hazards exist for upper limbs		c
	Hazards exist for whole body		d
3.2	Safety-related stop function in MO 2 or MO 3 (release of enabling device)	SF 07-1	
	If work zone is not accessible at all		None
	Hazards exist for upper limbs		c
	Hazard exist for whole body		d
3.3	Prevention of unexpected start-up in MO 2 or MO 3 (non-actuated enabling device)	SF 07-2	
	If work zone is not accessible at all		None
	Hazards exist for upper limbs		c
	Hazards exist for whole body		d
3.4	Prevention of unexpected Start in MO 1, MO 2 or MO 3 (opened interlocked guards)	SF 08-1	
	If work zone is not accessible at all		None
	Hazards exist for upper limbs		c

Ta-bleNo.	Subject	Number of SF	PL_r
	Hazards exist for whole body		d
3.5	Safely limited speed (SLS) of linear, rotational and auxiliary axes	SF 16	
	Hazards exist for upper limbs		None
	Hazards exist for whole body		d, Cat 3
J.4	**Power operated workpiece clamping for machines with milling and/or turning operations**		
4.1	Safety-related stop function of clamping and support devices in MO 1, MO 2 or MO 3	SF 01	
	Movement ≤ 4 mm		None
	4 mm < Movement ≤ 20 mm		a
	Movement > 20 mm		c
4.2	Safety-related stop function initiated by detection of incorrectly clamped workpiece in MO 1, MO 2 or MO 3	SF 01	
	Workpiece cannot be ejected		None
	Workpiece can be ejected		a
4.3	Prevent start/restart function in MO 1, MO 2 or MO 3	SF 03	a
4.4	Safety-related stop function of clamping and support devices in MO 2 or MO 3 (by released enabling device, two-hand-control or hold-to-run)	SF 07-1	
	Movements with small distances (≤4 mm)		None
	Movement of distance between 4 mm and 20 mm		a
	Movement exceeds 20 mm and no hand is required for fixation/adjustment		c
	Movement exceeds 20 mm and hand is required for fixation/adjustment		d, Cat 3
4.5	Prevention of unexpected start-up of clamping and support device in MO 2 or MO 3	SF 07-2	
	Movements with small distances (≤ 4 mm)		None
	Movement of distances between 4 mm and 20 mm		a
	Movements with larger distances (> 20 mm)		d, Cat 3
4.6	Prevention of unexpected start-up of clamping and unclamping movements in MO 1, MO 2 or MO 3	SF 08-1	
	Movements with small distances (≤ 4 mm)		None
	Movement of distances between 4 mm and 20 mm		a
	Movements with larger distances (> 20 mm)		d, Cat 3
4.7	Prevention of unexpected unclamping of workpiece initiated by any machine movement in MO 1, MO 2 or MO 3	SF 08-1	
	Manual clamping systems		None
	Workpiece cannot be ejected		a
	Workpiece can be ejected		d, Cat 3
4.8	Prevention of unexpected unclamping of workpiece due to gravity in MO 1, MO 2 or MO 3	SF 08-2	
	No hazard by gravity		None
	Hazard by gravity: Operator not working under gravity axes		c
	Hazard by gravity: Operator is working under gravity axes		d, Cat 3
4.9	Limited workpiece speed of the workpiece clamping device in MO 1, MO 2 or MO 3	SF 16	
	Clamping device is designed for maximum speed of the NC-axes		None

Table No.	Subject	Number of SF	PL_r
	Automatic workpiece feeding by pallet systems with different workpieces and clamping means		a
	Manual workpiece feeding		a
4.10	Limited workpiece speed in MO 2 or MO 3	SF 16	See Table J.17, 17.3 and 17.4
4.11	Monitoring of workpiece proportional technology – clamping pressure in MO 1, MO 2 or MO 3	SF 16	
	Automatic workpiece feeding		a
	Manual workpiece feeding		a
4.12	Monitoring of workpiece data internal and external gripping/clamping/chucking in MO 1, MO 2 or MO 3 on turning application	SF 16	
	Automatic workpiece feeding		a
	Manual workpiece feeding		a
4.13	Prevention of unexpected unclamping movement or depressurizing initiated by rotating /moving workpiece in MO 1, MO 2 or MO 3	*SF 08-1*	
	Manual clamping systems		None
	Workpiece cannot be ejected		None
	Workpiece can be ejected		PLr = d, Cat 3
J.5	**Tailstock**		
5.1	Safety-related stop function initiated by open of interlocked guards/deactivated protective devices in MO 1, MO 2 or MO 3	SF 01	c
5.2	Safety-related stop function initiated by release of enabling device, two-hand control or hold-to-run control device in MO 2 or MO 3	SF 07-1	c
5.3	Prevention of unexpected start-up in MO 2 or MO 3 initiated by non-actuated enabling device, two-hand-control or hold-to-run control device	SF 07-2	d, Cat 3
5.4	Prevention of unexpected start-up in MO 1, MO 2 or MO 3 initiated by open interlocked guards	SF 08-1	d, Cat 3
5.5	Safely limited speed (SLS) of linear, rotational and auxiliary axes	SF 16	
	Hazards exist for upper limbs		None
	Hazards exist for whole body		d, Cat 3
J.6	**Handling devices for workpiece loading and unloading, workpiece transfer device, pallet changer**		
6.1	Safety-related stop function for linear movement (e.g. lift/lowering) and/or rotational movement in MO 1, MO 2 or MO 3	SF 01	c
6.2	Prevent start/restart function initiated by an incorrect loaded pallet/workpiece in MO 1, MO 2 or MO 3	SF 03	
	Manually loaded by operator		None
	Automatically loaded		a
6.3	Safety-related stop function initiated by release of enabling, two-hand-control or hold-to-run control device in MO 2 or MO 3	SF 07-1	c
6.4	Prevention of unexpected start-up in MO 2 or MO 3 initiated by non-actuated enabling device, two-hand-control or hold-to-run control device	SF 07-2	d, Cat 3
6.5	Prevention of unexpected start-up in MO 1, MO 2 or MO 3 initiated by open interlocked guards	SF 08-1	d, Cat 3
6.6	Safely limited speed (SLS) of linear, rotational and auxiliary axes	SF 16	

Table No.	Subject	Number of SF	PL_r
	Hazards exist for upper limbs		None
	Hazards exist for whole body		d, Cat 3
J.7	**Bar feed device**		
7.1	Safety-related stop function in MO 1, MO 2 or MO 3 initiated by open interlocked guards	SF 01	c
7.2	Safety-related stop function in MO 2 or MO 3 initiated by release of enabling device, two-hand-control or hold-to-run control device	SF 07-1	c
7.3	Prevention of unexpected start-up in MO 2 or MO 3 initiated by non-actuated enabling device, two-hand-control or hold-to-run control device	SF 07-2	d, Cat 3
7.4	Prevention of unexpected start-up in MO 1, MO 2 or MO 3 initiated by open interlocked guards	SF 08-1	d, Cat 3
7.5	Safely limited speed (SLS) of linear, rotational and auxiliary axes	SF 16	
	Hazards exist for upper limbs		None, see remarks
	Hazards exist for whole body		d, Cat 3
J.8	**Pallet clamping and movement on machines with milling and turning operation**		
8.1	Safety-related stop function initiated by incorrect clamped pallet or unbalance detection in MO 1, MO 2 or MO 3	SF 01	a
8.2	Prevent start/restart function initiated by incorrect clamped pallet in MO 1, MO 2 or MO 3	SF 03	a
8.3	Prevention of unexpected start-up of unclamping movements in MO 1, MO 2 or MO 3 initiated by open interlocked guards	SF 08-1	
	Pallet position horizontal; short presence in hazard zone; pallet may fall out without hazard		a
	Pallet position horizontal; presence in hazard zone not short; pallet may fall out without hazard		b
	Pallet in any position; short presence in hazard zone; pallet may fall out		d, Cat 3
8.4	Prevention of unexpected start-up of unclamping movement in MO 1	SF 08-1	
	Pallet cannot be ejected		a
	Pallet can be ejected		d, Cat 3
8.5	Prevention of unexpected unclamping of pallet clamping in MO 1, MO 2 or MO 3 initiated by gravity	SF 08-2	
	Horizontal pallet position, short presence		a
	Horizontal pallet position, presence is not short		b
	Slant or pending pallet position		d, Cat 3
8.6	Safety-related stop function of movement from clamping and support devices initiated by the release of the locking device of the guard locking of the closed guard	SF 01	
	Movements with small distances (≤ 4 mm)		none
	Movement with distances > 4mm		c
8.7	Prevention of unexpected start-up of movement from clamping and support devices initiated by open interlocked guards	SF 08-1	
	Movements with small distances (≤ 4 mm)		none
	Movement with distances > 4mm		D, Cat 3
J.9	**Hazardous movement of the tool changer**		
9.1	Safety-related stop function, initiated by open interlocked guards in MO 1, MO 2 or MO 3	SF 01	c

Table No.	Subject	Number of SF	PL_r
9.2	Safety-related stop function in MO 2 or MO 3 initiated by release of enabling device, two-hand-control or hold-to-run control device	SF 07-1	c
9.3	Prevention of unexpected start-up in MO 2 or MO 3 initiated with non-actuated enabling device, two-hand-control or hold-to-run control device	SF 07-2	d, Cat 3
9.4	Prevention of unexpected start-up in MO 1, MO 2 or MO 3 initiated by open interlocked guards	SF 08-1	d, Cat 3
9.5	Safely limited speed (SLS) of linear, rotational and auxiliary axes	SF 16	
	Hazards exist for upper limbs		None, see remarks
	Hazards exist for whole body		d, Cat 3
J.10	**Hazardous movement of the tool magazine**		
10.1	Safety-related stop function, initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3	SF 01	c
10.2	Safety-related stop function initiated by release of enabling, two-hand-control or hold-to-run control device in MO 2 or MO 3	SF 07-1	c
10.3	Prevention of unexpected start-up initiated with non-actuated enabling, two-hand-control or hold-to-run control device in MO 2 or MO 3	SF 07-2	d, Cat 3
10.4	Prevention of unexpected start-up initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3	SF 08-1	d, Cat 3
10.5	Safely limited speed (SLS) of linear, rotational and auxiliary axes	SF 16	
	Hazards exist for upper limbs		None
	Hazards exist for whole body		d, Cat 3
J.11	**Chip conveyor in any case of intended use**		
11.1	Safety-related stop function initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3	SF 01	c
11.2	Safety-related stop function initiated by release of enabling, two-hand-control or hold-to-run control device in MO 2 or MO 3	SF 07-1	c
11.3	Prevention of unexpected start-up initiated with non-actuated enabling, two-hand-control or hold-to-run control device in MO 2 or MO 3	SF 07-2	
	Chip conveyor not inside accessible work zone		c
	Chip conveyor inside accessible work zone		d, Cat 3
11.4	Prevention of unexpected start-up initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3	SF 08-1	
	Chip conveyor not inside accessible work zone		c
	Chip conveyor inside accessible work zone		d, Cat 3
J.12	**Coolant, chip flushing with low-pressure 0 to 0,5 MPa or high-pressure exceeding 0,5 MPa**		
12.1	Safety-related stop function initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3	SF 01	
	Low-pressure		a
	High-pressure		c
12.2	Prevention of unexpected start-up initiated by open guards or deactivated protective devices in MO 1, MO 2 or MO 3	SF 08-1	
	Low-pressure: Operator does not directly stay in the coolant flow		a
	Low-pressure: Operator directly stay in the coolant flow		b
	High-pressure		d, Cat 3
J.13	**Power-operated guards for access by persons**		

Table No.	Subject	Number of SF	PL_r
13.1	Safety-related stop function of power operated guard initiated by a protective device	SF 01	
	Forces <75 N and kinetic energy <4 J		None
	Forces <150 N and kinetic energy <10 J and automatic reversing		c
	Other		d
13.2	Safety-related stop function of power operated guard with non-actuated enabling, two-hand-control or hold-to-run control device	SF 07-1	c
13.3	Prevention of unexpected start-up initiated with non-actuated enabling, two-hand-control or hold-to-run control device in MO 2 or MO 3	SF 07-2	d
13.4	Prevention of unexpected start-up of power operated guard initiated by deactivated protective devices	SF 08-1	
	Forces <75 N and kinetic energy ≤4 J		None
	Other		d
13.5	Safely limited speed of power operated guards for NC controlled axes	SF 16	d, at least Cat 2
J.14	**Extinguishing system for machines with interlocked guards**		
14.1	Safety-related stop function of coolant supply with interlocked guards closed initiated by the extinguishing system in MO 1	SF 01	a
14.2	Safety-related stop function of extraction system with closed interlocked guards initiated by the extinguishing system	SF 01	a
14.3	Safety-related stop function of sealing-off (shut-off valve in extraction pipe) of extraction system with interlocked guards being closed, initiated by the extinguishing system	SF 01	a
14.4	Safety-related stop function of machining process inclusive chip conveyor with interlocked guards being closed, initiated by the extinguishing system	SF 01	a
14.5	Local control functions to release the locking devices of guard locking for access to the hazard zone	SF 04	c
14.6	Prevention of unexpected start-up of the extinguishing process with oxygen displacing gases in MO 1, MO 2 or MO 3	SF 08-1	
	For machines with non-accessible the work zone		c
	For machines with accessible work zone		d, Cat 3
14.7	Prevention of unexpected start-up of the machine initiated by the fire extinguishing system in MO 1	SF 08-1	a
14.8	Local control function to monitor the volume of the exhaust system initiated by measuring the exhaust volume by pressure or flow rate during machining	SF 04	a
J.15	**Selection of MO (not applicable to Group 1 machines)**		
15.1	Selection of mode of operation initiated by opening of the interlocked guards and the MO selection device	SF 11	
	When only MO 1 and MO 2 are available		a
	When more than two MOs are available		c
15.2	Selection of authorization, to ensure that only one operator control station is enabled at a time	SF 11	a
J.16	**Emergency stop**		
16.1	Emergency stop: For movement controlled with safety function lower than PL = c, if required, a separated emergency stop function shall have the same PLr that means different parts	SF 14	a/b
	All others		c
J.17	**Control functions**		

Table No.	Subject	Number of SF	PL_r
17.1	Start- and restart function to initiate execution (e.g. of a program) initiated in combination with closed interlocked guard, activated protective device, actuated enabling device or two-hand-control	SF 03	
	Group 3 and group 4 machines in MO 1, MO 2 and MO 3		a
	Group 3 and group 4 machines in MO Service		b
17.2	Local control functions to release the locking devices of guard locking for access to the hazard zone	SF 04	a
17.3	Safely limited speed (SLS) of linear, rotational and auxiliary NC controlled axes	SF 16	
	Hazards exist for upper limbs		none, see remarks
	Hazards exist for whole body		d, Cat 3
17.4	Safely limited speed (SLS) of tool spindle or workholding spindle	SF 16	
	Hazards exist for upper limbs		none, see remarks
	Hazards exist for whole body		d, Cat 3
17.5	Fluctuations or loss and return of power supply initiated by interruption in MO 1, MO 2 or MO 3	SF 17	a
17.6	Safety-related stop function of machining process with interlocked guards being closed (normal stop)	SF 01	a
17.7	Start and restart function to execute (e.g. of a program) initiated by pressing start button in MO 0	SF 03	c
17.8	Safety related stop function (normal stop) initiated by pressing stop button in MO 0	SF 01	c
17.9	Safety related stop function by releasing a direction control or hold-to-run control in conjunction with an enabling device	SF 01	a
17.10	Manual reset function	SF 02	a
17.11	Prevention of unintended movement of machine parts into an adjacent not authorized work zone	SF 16	d
J.18	**Hazardous movements in the work zone**		
18.1	Safety-related stop function initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3	SF 01	c
18.2	Safety-related stop function initiated by release of enabling, two-hand-control or hold-to-run control device in MO 2 or MO 3	SF 07-1	c
18.3	Prevention of unexpected start-up initiated with non-actuated enabling, two-hand-control or hold-to-run control device in MO 2 or MO 3	SF 07-2	
	in case of short presence		c
	otherwise		d, Cat 3
18.4	Prevention of unexpected start-up initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3	SF 08-1	
	in case of short presence		c
	otherwise		d, Cat 3
18.5	Safely limited speed (SLS) of linear, rotational and auxiliary axes	SF 16	
	Hazards exist for upper limbs		None
	Hazards exist for whole body		d, Cat 3
J.19	**Hazardous movements in the maintenance area**		
19.1	Safety-related stop function, initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3.	SF 01	c

Ta-bleNo.	Subject	Number of SF	PL_r
19.2	Safety-related stop function initiated by release of enabling, two-hand-control or hold-to-run control device in MO 2 or MO 3	SF 07-1	c
19.3	Prevention of unexpected start-up initiated with non-actuated enabling, two-hand-control or hold-to-run control device in MO 2 or MO 3	SF 07-2	
	in case of short presence		c
	otherwise		d, Cat 3
19.4	Prevention of unexpected start-up initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3	SF 08-1	
	in case of short presence		c
	otherwise		d, Cat 3
19.5	Safely limited speed (SLS) of linear, rotational and auxiliary axes	SF 16	
	Hazards exist for upper limbs		None
	Hazards exist for whole body		d, Cat 3
J.20	**Safety interface for loading system – Automation safety features at the interface**		
20.1	Safety-related stop function initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3	SF 01	c, Cat 3
20.2	Prevention of unexpected start-up initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3	SF 08-1	d, Cat 3
20.3	Emergency stop input/output signals	SF 14	c, Cat 3
J.21	**Grinding operation on a milling machine**		
21.1	Limited speed initiated by safety related tool parameter in MO 1, MO 2 or MO 3	SF 16	a
J.22	**Compressed air for cleaning and measuring processes**		
22.1	Safety-related stop function initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3	SF 01	a
22.2	Safety-related stop function initiated by release of enabling, two-hand-control or hold-to-run control device in MO 2 or MO 3	SF 07-1	a
22.3	Prevention of unexpected start-up initiated with non-actuated enabling, two-hand-control or hold-to-run control device in MO 2 or MO 3	SF 07-2	b
22.4	Prevention of unexpected start-up initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2, MO 3	SF 08-1	b

J.2 Description of safety functions

Safety function, according to ISO 13849-1:2015, Table 8 and Table 9	Numbering of safety function in this document
Safety-related stop function initiated by safeguard	SF 01
Manual reset function	SF 02
Start/restart function	SF 03
Local control function	SF 04
Enabling device function	SF 07–1/SF 07–2
Prevention of unexpected start-up	SF 08–1/SF 08–2
Control modes and mode selection	SF 11
Emergency stop function	SF 14
Safety-related parameter such as speed, temperature or pressure	SF 16
Fluctuations, loss and restoration of power sources	SF 17

NOTE Designing the electrical control system according to IEC 62061 can generally achieve the same safety level of any safety function in Annex J as the application of ISO 13849-1. The result with IEC 62061 is a SIL with a defined PFHD-Value (IEC 62061:2005, Table 3). This PFHD-value is also defined in ISO 13849-1:2015, Table 2, and leads to a PL. SIL 1 refers to a PL = c or PL = b (see ISO 13849-1:2015, Table 3). Bruises and/or lacerations without complication is classified as S1 in ISO 13849-1 and only S1 injuries, according ISO 13849-1, lead to a required PL = b. If the result of class (CL), see in IEC 62061:2005, Table A.6, with SE2 is 11 or with SE1 is 14, than the required PL = b according ISO 13849-1, else the required PL = c. "PL = a" has no correspondence to IEC 62061 but it is defined with other measures (IEC 62061:2005, Table A.6, see OM) so it is definable with S3 and CL ≤ 7 or SE2 and CL ≤ 10 or SE1 and CL ≤ 13.

J.3 Safety related parameter

The input of safety related parameter usually requires that the operator inserts them. Errors in manual inputting of safety-related parameter in programmable electronic systems can lead to a hazardous situation. Moreover, in those cases, parameter retransmission and/or manual confirmation shall be done (see ISO 13849-1:2015, 4.6.4 and 5.2.7). Possible solutions for data checking can be:

— a data checking system within the safety-related control system, e.g.:

  — check of limits,

  — format and/or logic input values,

  — data duplexing/cross-check;

— a data checking by an acceptance test with checksums. The acceptance test is used to check that the safety functions have been correctly parameterized. Using the acceptance test, potential configuring errors are to be identified and the correct configuring is documented.

J.4 Tables of safety functions

Table J.1 — Explanation on how to read the tables of safety functions (Table J.2 to J.22)

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
1.1	Requirement (mandatory)	SF XX	— notes — major known accident causes — hazardous situations	Explanation of which safety function is applicable and when.	required performance level for that requirement

Table J.2 — Tool spindle rotation and tool clamping device

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
2.1	**Prevent start/restart function** initiated by an incorrectly clamped tool in MO 1, MO 2, MO 3.	SF 03			PLr = a
2.2	**Prevention of unexpected start-up of un-clamping movement of the tool-gripper** initiated by tool spindle speed $n > 0$ in MO 1, MO 2, MO 3.	SF 08-1	The correct function is frequently tested in MO 1. Because of sensor flickering it is possible to control a threshold limit (e.g. 1 r/min).	In MO 1 protection by guards	PLr = b
				In MO 2, MO 3	PLr = c
2.3	**Limited spindle speed** initiated by safety related tool parameter in MO 1, MO 2, MO 3.	SF 16	Fault incident may occur unexpectedly in MO 2 or MO 3. Incorrect input of tool parameters is most common source of failure. The maximum permitted processing speed depends on constructive limitations of the spindle, the clamping means and the size, mass and unbalance of the specific tool. These limitations are given by the manufacturer of the machine.		PLr = a
2.4	**Limited spindle speed** initiated by safety related parameter in MO 2, MO 3.	SF 16			See Table J.17, 17.3 and 17.4

Table J.3 — Gravity-loaded or slant axes

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
3.1	**Safety-related stop function** initiated by opening of the interlocked guards or other protective devices in MO 1, MO 2, MO 3. The axis is brought to a standstill and is then held in position by, e.g. — a self-locking or braking device which acts in the de-energized state, or — in energized state, if there are integrated safety functions in the control unit, a stop category 2 (IEC 60204-1) with a monitored SOS at standstill shall be done.	SF 01		If the work zone is not accessible at all (e.g. guards); safe by design	none
			see Annex G, Table G.1, G1.1	Hazards exist for upper limbs	PLr = c
			see Annex G, Table G.1, G1.2	Hazards exist for whole body	PLr = d
3.2	**Safety-related stop function** initiated by release of enabling device or release of two-hand control device in case of open interlocked guards or other protective devices in MO 2, MO 3. The axis is brought to a standstill and is then held in position by, e.g. — a self-locking or braking device which acts in the de-energized state, or — in energized state, if there are integrated safety functions in the control unit, a Stop category 2 (IEC 60204-1) with a monitored SOS at standstill shall be done.	SF 07-1		If the work zone is not accessible at all, safe by design (e.g. guards)	none
			see Annex G, Table G.1, G1.1	Hazards exist for upper limbs	PLr = c
			see Annex G, Table G.1, G1.2	Hazards exist for whole body	PLr = d
3.3	**Prevention of unexpected start-up** initiated with non-actuated enabling device or two-hand-control in case of open interlocked guards or other protective devices in MO 2, MO 3. At standstill, the axis is held in place, e.g. by a clamping or braking device which acts in the de-energized state or by a safe axis control.	SF 07-2		If the work zone is not accessible at all, safe by design (e.g. guards)	none
			see Annex G, Table G.1, G1.1	Hazard exist for upper limbs	PLr = c
			see Annex G, Table G.1, G1.2	Hazards exist for whole body	PLr = d

Table J.3 *(continued)*

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
3.4	**Prevention of unexpected start-up** initiated with open interlocked guards or other protective devices in MO 1, MO 2, MO 3. At standstill, the axis is held in place, e.g. by a self-locking or braking device which acts in the de-energized state or by a safe axis control.	SF 08-1		If the work zone is not accessible at all, safe by design (e.g. guards)	none
			see Annex G, Table G.1, G1.1	Hazard exist for upper limbs	PLr = c
			see Annex G, Table G.1, G1.2	Hazards exist for whole body	PLr = d
3.5	**Safely limited speed (SLS) of linear, rotational and auxiliary axes** initiated by — in MO 2 or MO 3 with enabling device actuated, — in MO 2, MO 3 with a hold-to-run control device actuated, — in MO 1, MO 2, MO 3 with two-hand control, or — in MO 2 or MO 3 with electronic handwheel.	SF 16	A speed monitoring in the safety function does not need to be considered. The normal functions (position controller or speed controller) are sufficient in combination with one of the listed initiating devices in PLr = d, Category 3.	Hazards exist for upper limbs	None, see remarks
			For rotational axes, the peripheral speed has to be considered at the maximum radius	Hazards exist for whole body	PLr = d Category 3

Table J.4 — Power operated workpiece clamping for machines with milling and/or turning operations

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
4.1	**Safety-related stop function of clamping and support devices** initiated by the release of the locking device of the guard locking of the closed guard or the initiation of the protective devices (consider distances according to ISO 13857:2019) and leads to a stop of the hazardous movements of the clamping and support devices in MO 1, MO 2 or MO 3.	SF 01		Movements are with small distances (≤ 4 mm), safe by design	none
				Clamping movement distance between 4 mm and 20 mm	PLr = a
				Automatic movements of the workpiece clamping device are prevented in case of open interlocked guards or activated protective devices, if the workpiece clamping movement exceeds 20 mm (ISO 13857:2019).	PLr = c
4.2	**Safety-related stop function** initiated by the detection of an incorrectly clamped workpiece in MO 1, MO 2, MO 3.	SF 01		Workpiece cannot be ejected, e.g. collecting device provided, mass very large or speed/rotational speed low	none
				Workpiece can be ejected	PLr = a
4.3	**Prevent start/restart function** initiated by an incorrectly clamped workpiece in MO 1, MO 2, MO 3.	SF 03			PLr = a
4.4	**Safety-related stop function of clamping and support devices** initiated by release of — enabling device, — two-hand-control, or — hold-to-run control device in case of open interlocked guards or other protective devices in MO 2 or MO 3.	SF 07-1		Movements are with small distances (≤ 4 mm), safe by design	none
				Clamping movement distance between 4 mm and 20 mm	PLr = a
			If there is a three-step enabling device, full compression of a three-step enabling device can lead to Emergency stop or to the activation of the movement in the opposite direction. NOTE See also 5.2.5.5 b) 3) and 5.2.5.5 b) 4).	Clamping movement exceeds 20 mm and no hand is required at the workpiece for fixation or adjustment	PLr = c
				Clamping movement exceeds 20 mm and a hand is required at the workpiece for fixation or adjustment	PLr = d, Category 3
4.5	**Prevention of unexpected start-up of clamping and support devices** initiated with non-actuated — enabling device, — two-hand-control, or — hold-to-run control device in case of open interlocked guards or other protective devices in MO 2 or MO 3.	SF 07-2		Movements are with small distances (≤4 mm), safe by design	none
				Clamping movement distance between 4 mm and 20 mm	PLr = a
				Movements with distances > 20 mm	PLr = d, Category 3

Table J.4 *(continued)*

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
4.6	**Prevention of unexpected start-up of clamping and unclamping movements** initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2, MO 3.	SF 08-1		Movements are with small distances (≤4 mm), safe by design	none
				Clamping movement distance between 4 mm and 20 mm	PLr = a
				Movements with distances > 20 mm	PLr = d Category 3
4.7	**Prevention of unexpected unclamping of workpiece** initiated by any machine movement in MO 1, MO 2, MO 3.	SF 08-1		Manual clamping systems	none
				Workpiece cannot be ejected	PLr = a
				Workpiece can be ejected.	PLr = d, category 3
4.8	**Prevention of unexpected unclamping of workpiece due to gravity** initiated by power failure in MO 1, MO 2, MO 3.	SF 08-2	**No hazard by gravity:** If clamping/unclamping function is done horizontally and the workpiece cannot be swivelled, no hazard from gravity can occur.		none
			Hazard by gravity: Fall protection may be made by either a spring mechanism or fall protection by hydraulic cylinder and non-return valve (depending on workpiece weight), or by a hydraulic swing clamping element with decoupled rotational and axial movement.	Operator is not working under the workpiece during the clamping/unclamping process.	PLr = c
			Hazard by gravity: Fall protection may be made by either a spring mechanism or fall protection by hydraulic cylinder and non-return valve (depending on workpiece weight), or by a hydraulic swing clamping element with decoupled rotational and axial movement.	Operator is working under the workpiece during the clamping/unclamping process.	PLr = d, Category 3

Table J.4 *(continued)*

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
4.9	**Limited speed of the workpiece clamping device** initiated by safety related parameter of workpiece clamping device in MO 1, MO 2, MO 3, e.g. speed limitation for turning operation.	SF 16		Monitoring of the movement is not required if the workpiece clamping device design considers the maximum speed and rotational speed of the NC-axes which cause the movements.	none
			Automatic workpiece feeding by pallet systems with different workpieces and clamping means: The selection of different safe parameters for speed and rotational speed monitoring is required if the clamping device is not suitable for the maximum speeds or rotational speeds. Incorrect input of rotational speed parameters is the most common source of error.	Rotational speed parameters may be provided by a central control level of the machine.	PLr = a
			Manual workpiece feeding The speed and rotational speed monitoring shall be entered into the machine control system. It shall not be possible to change the speed limit by simple means.	Rotational speed parameters may be provided by manual data input.	PLr = a
4.10	**Limited axes speed** initiated by safety related parameter in MO 2, MO 3.	SF 16			See Table J.17, 17.3 and 17.4
4.11	**Safety related parameter:** Monitoring of workpiece proportional technology – clamping pressure in MO 1, MO 2, MO 3: If the actual pressure of the workpiece clamping device is monitored outside acceptable tolerance range, the stopping of the workpiece drive performs according to IEC 60204-1, depending on the technique applied independent on the position of the interlocked guard. Manual or automatic workpiece clamping device.	SF 16	**Automatic workpiece feeding by pallet systems with different workpieces and clamping means:** The selection of different safe parameters for proportional technology – clamping pressure is required. Incorrect input of the pressure parameters is the most common source of error.	Pressure parameters may be provided by a central control of the machine.	PLr = a
			Manual workpiece feeding: The pressure monitoring shall be entered into the machine control system. It shall not be possible to change the speed limit by simple means.	Pressure parameters may be provided by manual data input.	PLr = a

Table J.4 *(continued)*

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
4.12	**Safely related parameter:** Monitoring of workpiece data internal and external gripping/clamping/chucking in MO 1, MO 2, MO 3 on turning application: If the wrong direction of the clamping movement is detected (positions outside the acceptable tolerance range, see 5.2.5.6 f), the stopping of the workpiece drive performs according to IEC 60204-1, depending on the technology applied independent on the position of the interlocked guard. Manual or automatic workpiece clamping device.	SF 16	**Automatic workpiece feeding by pallet systems with different workpieces and clamping means:** The required selection of the direction of the clamping movement shall be detected. Incorrect input of the parameters is the most common source of error.	Workpiece parameters may be provided by a central control of the machine.	PLr = a
			Manual workpiece feeding: The required selection of the direction of the clamping movement shall be detected. It shall not be possible to change the speed limit by simple means.	Workpiece parameters may be provided by manual data input.	PLr = a
4.13	**Prevention of unexpected unclamping movement or depressurizing** initiated by rotating/moving workpiece in MO 1, MO 2, MO 3.	SF 08-1		Manual clamping systems	none
				Workpiece cannot be ejected, e.g. collecting device provided, mass very large or speed/rotational speed low	none
			Monitoring of speed $n = 0$ (threshold limit, e.g. 1 r/min because of sensor flickering) or axis velocity $v = 0$ (threshold limit, e.g. 1 mm/min because of sensor flickering) shall be done while and before unclamping or depressurizing.	Workpiece can be ejected by centrifugal force due to the speed or axis motion of the workpiece-bearing axis. Unclamping or depressurizing the workpiece shall only be done with speed $n = 0$ or axis velocity $v = 0$	PLr = d Category 3

Table J.4 *(continued)*

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
4.14	**Prevention of unexpected unclamping of workpiece** initiated by gravity loaded workpiece position in MO 1, MO 2, MO 3.	SF	**No hazard by gravity:** If clamping/unclamping function is done horizontally and the workpiece cannot be swivelled, no hazard from gravity can occur.		none
		08-2	**Low Hazard by gravity:** — the workpiece weight is less than 7,5 kg or — the workpiece weight is less than 25 kg and clamping/unclamping is only possible if the interlocked guards are closed (PLr d, Cat. 3) or — the workpiece is held by a gripper of a loading system during the clamping / unclamping process.	Work zone is not accessible, and operator is not working under the workpiece during the clamping/unclamping process.	PLr = a
			Hazard by gravity: If the work zone is not accessible.	Operator is not working under the workpiece during the clamping / unclamping process.	PLr = c
			Hazard by gravity: If the work zone is accessible.	Operator is working under the workpiece during the clamping / unclamping process.	PLr = d, Category 3

Table J.5 — Tailstock

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
5.1	**Safety-related stop function** initiated by open interlocked guards or de-activated protective devices in MO 1, MO 2, MO 3.	SF 01			PLr = c
5.2	**Safety-related stop function** initiated by release — of enabling device, — two-hand-control, or — hold-to-run control device in case of open interlocked guards or other protective devices in MO 2 or MO 3.	SF 07-1			PLr = c
5.3	**Prevention of unexpected start-up** initiated with non-actuated — enabling device, — two-hand-control, or — hold-to-run control device in case of open interlocked guards or other protective devices in MO 2 or MO 3.	SF 07-2			PLr = d, category 3
5.4	**Prevention of unexpected start-up** initiated by open interlocked guards or de-activated protective devices in MO 1, MO 2, MO 3.	SF 08-1			PLr = d, category 3

Table J.5 *(continued)*

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
5.5	**Safely limited speed (SLS) of linear, rotational and auxiliary axes** initiated by — in MO 2 or MO 3 with enabling device actuated, — in MO 2 or MO 3 with a hold-to-run control device actuated, — in MO 1, MO 2, MO 3 with two-hand control or — in MO 2 or MO 3 with electronic handwheel.	SF 16	A speed monitoring in the safety function does not need to be considered. The normal functions (position controller or speed controller) are sufficient in combination with one of the listed initiating devices in PLr = d, Category 3.	Hazards exist for upper limbs	None, see remarks
			For rotational axes, the peripheral speed has to be considered at the maximum radius.	Hazards exists for the whole body	PLr = d Category 3

Table J.6 — Handling devices for workpiece loading and unloading, workpiece transfer device, pallet changer

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
6.1	**Safety-related stop function for linear movement and/or rotational movement** initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2, MO 3.	SF 01			PLr = c
6.2	**Prevent start/restart function** initiated by an incorrect loaded pallet/workpiece in MO 1, MO 2, MO 3.	SF 03	Fault incident can be prevented by monitoring of correct pallet/workpiece position by operator. Guards are closed and form-fitted pallet/workpiece	Manual loaded by operator	none
				Automatically loaded pallet/workpiece	PLr = a
6.3	**Safety-related stop function** initiated by release of enabling device or two-hand-control or hold-to-run control device in case of open interlocked guards or other protective devices in MO 2 or MO 3.	SF 07-1			PLr = c
6.4	**Prevention of unexpected start-up** initiated with non-actuated enabling device or two-hand-control or hold-to-run control device in case of open interlocked guards or other protective devices in MO 2 or MO 3.	SF 07-2			PLr = d, Category 3
6.5	**Prevention of unexpected start-up** initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3.	SF 08-1			PLr = d, Category 3
6.6	**Safely limited speed (SLS) of linear, rotational and auxiliary axes** initiated by: — in MO 2 or MO 3 with enabling device actuated, — in MO 2 or MO 3 with a hold-to-run control device actuated, — in MO 1, MO 2, MO 3 with two-hand control, or — in MO 2 or MO 3 with electronic handwheel.	SF 16	A speed monitoring in the safety function does not need to be considered. The normal functions (position controller or speed controller) are sufficient in combination with one of the listed initiating devices in PLr = d, Category 3.	Hazards exist for upper limbs	None, see remarks
			For rotational axes, the peripheral speed has to be considered at the maximum radius.	Hazards exist for whole body	PLr = d, Category 3

Table J.7 — Bar feed device

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
7.1	**Safety-related stop function** initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3.	SF 01			PLr = c
7.2	**Safety-related stop function** initiated by release — of enabling device, — two-hand-control, or — hold-to-run control device in case of open interlocked guards or other protective devices in MO 2 or MO 3.	SF 07-1			PLr = c
7.3	**Prevention of unexpected start-up** initiated with non-actuated — enabling device, — two-hand-control, or — hold-to-run control device in case of open interlocked guards or other protective devices in MO 2 or MO 3.	SF 07-2			PLr = d, Category 3
7.4	**Prevention of unexpected start-up** initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3.	SF 08-1			PLr = d, Category 3

Table J.7 *(continued)*

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
7.5	**Safely limited speed (SLS) of linear, rotational and auxiliary axes** initiated by: — in MO 2 or MO 3 with enabling device actuated, — in MO 2 or MO 3 with a hold-to-run control device actuated, — in MO 1, MO 2, MO 3 with two-hand control, or — in MO 2 or MO 3 with electronic handwheel	SF 16	A speed monitoring in the safety function does not need to be considered. The normal functions (position controller or speed controller) are sufficient in combination with one of the listed initiating devices in PLr = d, Category 3.	Hazards exist for upper limbs	None, see remarks
			For rotational axes, the peripheral speed has to be considered at the maximum radius.	Hazards exist for whole body	PLr = d, Category 3

Table J.8 — Pallet clamping and movement on machines with milling and turning operation

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
8.1	**Safety-related stop function** initiated by an incorrect clamped pallet or unbalance detection of process observation in MO 1, MO 2, MO 3.	SF 01			PLr = a
8.2	**Prevent start/restart function** initiated by an incorrectly clamped pallet in MO 1, MO 2, MO 3.	SF 03			PLr = a
8.3	**Prevention of unexpected start-up of unclamping movements** initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2, MO 3.	SF 08-1		— Pallet position horizontal, and release function takes place horizontally or angularly, — presence is short during the release process in the hazard zone, and — pallet may fall out, without hazard.	PLr = a
				— Pallet position horizontal, and release function takes place horizontally or angularly, — presence is not short during the release process in the hazard zone, and — pallet may fall out, without hazard.	PLr = b
				— Any position the pallet may fall out and — presence is short during the release process in the hazard zone.	PLr = d, Category 3
8.4	**Prevention of unexpected start-up of unclamping movement** initiated by movement of linear or rotational axes, NC-axes or hydraulic/pneumatic auxiliary axes in MO 1 with interlocked guards closed.	SF 08-1		Pallet cannot be ejected.	PLr = a
				Pallet can be ejected.	PLr = d, Category 3

Table J.8 *(continued)*

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
8.5	**Prevention of unexpected unclamping of pallet clamping** initiated by gravity in MO 1, MO 2, MO 3.	SF 08-2		— Pallet position horizontal, and release function takes place horizontally or angularly, where pallet may fall out, without hazard and — presence is short during the release process in the hazard zone.	PLr = a
				— Pallet position horizontal, and release function takes place horizontally or angularly, where pallet may fall out, without hazard and — presence is not short during the release process in the hazard zone.	PLr = b
				Pallet position slant or pending or horizontal, and release function takes place not horizontally or angularly.	PLr = d, Category 3
8.6	**Safety-related stop function of movement from clamping and support devices** initiated by the release of the locking device of the guard locking of the closed guard or the initiation of the protective devices (consider distances according to ISO 13857:2019) and leads to a stop of the hazardous movements of the clamping and support devices in MO 1, MO 2 or MO 3.	SF 01		Movements are with small distances (≤4 mm), safe by design	none
				Automatic movements of the pallet clamping device are prevented in case of open interlocked guards or activated protective devices, if the pallet clamping movement exceeds 4 mm (ISO 13857:2019).	PLr = c
8.7	**Prevention of unexpected start-up of movement from clamping and support devices** initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2, MO 3.	SF 08-1		Movements are with small distances (≤4 mm), safe by design	none
				Movements with distance > 4 mm	PLr = d, Category 3

Table J.9 — Hazardous movement of the tool changer

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
9.1	**Safety-related stop function** initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3.	SF 01			PLr = c
9.2	**Safety-related stop function** initiated by release — of enabling device, — two-hand-control, or — hold-to-run control device in case of open interlocked guards or other protective devices in MO 2 or MO 3.	SF 07-1			PLr = c
9.3	**Prevention of unexpected start-up** initiated with non-actuated — enabling device, — two-hand-control, or — hold-to-run control device in case of open interlocked guards or other protective devices in MO 2 or MO 3.	SF 07-2			PLr = d, Category 3
9.4	**Prevention of unexpected start-up** initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3.	SF 08-1			PLr = d, Category 3

Table J.9 *(continued)*

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
9.5	**Safely limited speed (SLS) of linear, rotational and auxiliary axes** initiated by: — in MO 2 or MO 3 with enabling device actuated, — in MO 2 or MO 3 with hold-to-run control device actuated, — in MO 1, MO 2, MO 3 with two-hand control, or — in MO 2 or MO 3 with electronic handwheel.	SF 16	A speed monitoring in the safety function does not need to be considered. The normal functions (position controller or speed controller) are sufficient in combination with one of the listed initiating devices in PLr = d, Category 3.	Hazards exist for upper limbs	None, see remarks
			For rotational axes, the peripheral speed has to be considered at the maximum radius.	Hazards exist for whole body	PLr = d, Category 3

Table J.10 — Hazardous movements of the tool magazine

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
10.1	**Safety-related stop function** initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3.	SF 01			PLr = c
10.2	**Safety-related stop function** initiated by release of — enabling device, — two-hand-control, or — hold-to-run control device in case of open interlocked guards or other protective devices in MO 2 or MO 3.	SF 07-1			PLr = c
10.3	**Prevention of unexpected start-up** initiated with non-actuated — enabling device, — two-hand-control, or — hold-to-run control device in case of open interlocked guards or other protective devices in MO 2 or MO 3.	SF 07-2			PLr = d, Category 3
10.4	**Prevention of unexpected start-up** initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3.	SF 08-1			PLr = d, Category 3

Table J.10 *(continued)*

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
10.5	**Safely limited speed (SLS) of linear, rotational and auxiliary axes** initiated by — in MO 2 or MO 3 with enabling device actuated, — in MO 2 or MO 3 with hold-to-run control device actuated, — in MO 1, MO 2, MO 3 with two-hand control, or — in MO 2 or MO 3 with electronic handwheel.	SF 16	A speed monitoring in the safety function does not need to be considered. The normal functions (position controller or speed controller) are sufficient in combination with one of the listed initiating devices in PLr = d, Category 3.	Hazards exist for upper limbs	None, see remarks
			For rotational axes, the peripheral speed has to be considered at the maximum radius.	Hazards exist for whole body	PLr = d, Category 3

Table J.11 — Chip conveyor in any case of intended use

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
11.1	**Safety-related stop function** initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3.	SF 01			PLr = c
11.2	**Safety-related stop function** initiated by release of — enabling device, — two-hand-control, or — hold-to-run control device in case of open interlocked guards or other protective devices in MO 2 or MO 3.	SF 07-1			PLr = c
11.3	**Prevention of unexpected start-up** initiated with non-actuated — enabling device, — two-hand-control, or — hold-to-run control device in case of open interlocked guards or other protective devices in MO 2 or MO 3.	SF 07-2		Chip conveyor system not inside “accessible work zone”.	PLr = c
				Chip conveyor system inside “accessible work zone”.	PLr = d, Category 3
11.4	**Prevention of unexpected start-up** initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3.	SF 08-1		Chip conveyor system not inside “accessible work zone”.	PLr = c
				Chip conveyor system inside “accessible work zone”.	PLr = d, Category 3

Table J.12 — Coolant, chip flushing with low pressure 0 MPa to 0,5 MPa or high pressure exceeding 0,5 MPa

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
12.1	**Safety-related stop function** initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3.	SF 01	When the metalworking fluid nozzles for low-pressure need to be set with guard open; this requires the coolant to be conveyed through the metalworking fluid nozzles. In this case, the operator shall wear suitable personal protective equipment (e.g. safety goggles).	Low-pressure	PLr = a
				High-pressure	PLr = c
12.2	**Prevention of unexpected start-up** initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3.	SF 08-1		Low-pressure The operator stays is not directly in the coolant flow.	PLr = a
				Low-pressure The operator stays direct in the coolant flow.	PLr = b
				High-pressure	PLr = d, Category 3

Table J.13 — Power-operated guards for access by persons

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
13.1	**Safety-related stop function** of power operated guard initiated by a protective device.	SF 01		Forces are less than 75 N and energy is equal to or less than 4 J, safe by design	none
				The door force can apply a static force of maximum 150 N and kinetic energy of maximum 10 J in combination with measures that initiate an automatic reversing.	PLr = c
				Other	PLr = d
13.2	**Safety-related stop function** of power operated guard with non-actuated — of enabling device, — two-hand-control, or — hold-to-run control device.	SF 07-1			PLr = c
13.3	**Prevention of unexpected start-up** initiated with non-actuated — enabling device, — two-hand-control, or — hold-to-run control device.	SF 07-2			PLr = d
13.4	**Prevention of unexpected start-up** of power operated guard initiated by deactivated protective devices.	SF 08-1		— Forces are less than 75 N and energy is equal to or less than 4 Joule or — the door force can apply a static force of maximum 150 N and kinetic energy of maximum 10 J in combination with measures that initiates an automatic reversing	none
				Other	PLr = d
13.5	**Safely limited speed (SLS) of power operated guards for NC controlled axes** The speeds of moved axes shall be monitored.	SF 16			PLr = d at least Category 2

Table J.14 — Extinguishing systems for machines with interlocked guards

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
14.1	**Safety-related stop function of coolant supply with interlocked guards closed** initiated by the extinguishing system in MO 1.	SF 01			PLr = a
14.2	**Safety-related stop function of extraction system with closed interlocked guards** initiated by the extinguishing system in MO 1.	SF 01			PLr = a
14.3	**Safety-related stop function of sealing-off (shut-off valve in extraction pipe) of extraction system with interlocked guards being closed,** initiated by the extinguishing system in MO 1.	SF 01			PLr = a
14.4	**Safety-related stop function of machining process inclusive chip conveyor with interlocked guards being closed**, initiated by the extinguishing system in MO 1.	SF 01			PLr = a
14.5	**Local control functions to release the locking devices of guard locking for access to the hazard zone** initiated by the extinguishing system in MO 1, MO2 or MO3.	SF 04	Prevention of backfire by keeping the interlocked guard closed in case of fire detection.		PLr = c
14.6	**Prevention of unexpected start-up of the extinguishing process with oxygen displacing gases** initiated by open interlocked guards in MO 1, MO 2 or MO 3.	SF 08–01		Machines with non-accessible work zone.	PLr = c
				Machines with accessible work zone (see 3.3.8).	PLr = d, Category 3
14.7	**Prevention of unexpected start-up of the machine** initiated by the fire extinguishing system in “not ready to operate mode” in MO 1.	SF 08-01			PLr = a

Table J.14 *(continued)*

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
14.8	**Local control function to monitor the volume of the exhaust system** initiated by measuring the exhaust volume by pressure or flow rate during machining.	SF 04	If the value not reached, a signal is issued that stops the machine at the end of cycle.		PLr = a

Table J.15 — Selection of MO (not applicable to Group 1 machines)

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
15.1	**Selection of mode of operation** initiated by opening of the interlocked guards and the MO selection device.	SF 11	The open interlocked guards and the enabling devices initiate the safety functions required for movement in the area. Therefore, the selection of a wrong mode of operation does not initiate a hazard.	When only MO 1 and MO 2 are available.	PLr = a
				When more than two MOs are available.	PLr = c
15.2	**Selection of authorization**, to ensure that only one operator control station is enabled at a time.	SF 11	If control devices are provided at several locations, (e.g. at the main control station and the hand-held pendant), only one control device shall be functional at one time, including the associated enabling device; see 5.2.4.5.2 f).		PLr = a

Table J.16 — Emergency stop

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
16.1	Emergency stop	SF 14	Design the emergency stop according to the requirements of IEC 60204-1:2016. The emergency stop function is an additional protective measure according to ISO 12100:2010. The emergency stop acts independent of the mode of operation on all moving machine parts and mediums as safety-related stop function (SF 01 and SF 07-1). Input two channel system because failure exclusion of short-circuit between conductors is not possible in a one channel system (see 5.8.6 and Figure 3).	For movement controlled (e.g. start / stop) with safety function lower than PL = c, if required, a separated emergency stop function shall have the same PLr that means different parts.	PLr = a/b
				All others	PLr = c

Table J.17 — Control functions

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
17.1	**Start and restart function to execute (e.g. of a program)** initiated in combination with — closed interlocked guard, — activated protective device, — actuated enabling device, or — two hand control NOTE For exception, see ISO 12100:2010, 6.3.3.2.5.	SF 03	Group 3 and Group 4 machines in MO 1, MO 2 and MO 3		PLr = a
			Group 3 and Group 4 machines in MO Service		PLr = b
17.2	**Local control functions to release the locking devices of guard locking for access to the hazard zone**	SF 04			PLr = a
17.3	**Safely limited speed (SLS) of linear, rotational and auxiliary NC controlled axes** initiated by — in MO 2 or MO 3 with enabling device actuated, — in MO 2 or MO 3 with a hold-to-run control device actuated, — in MO 1, MO 2, MO 3 with two-hand control, or — in MO 2 or MO 3 with electronic handwheel.	SF 16	A speed monitoring in the safety function does not need to be considered. The normal functions (e.g. position controller or speed controller) are sufficient in combination with one of the listed initiating devices in PLr = d, Category 3.	Hazards exist for upper limbs	none, see remarks
			For rotational axes, the peripheral speed has to be considered at the maximum radius.	Hazards exist for whole body	PLr = d, Category 3

Table J.17 *(continued)*

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
17.4	**Safely limited speed (SLS) of tool spindle or workholding spindle** initiated by — in MO 1, if it is possible to exceed the speed for which the guards are designed regarding penetration energy — in MO 2 or MO 3 with enabling device actuated, — in MO 2 or MO 3 with a hold-to-run control device actuated, — in MO 1, MO 2, MO 3 with two-hand control, or — in MO 2 or MO 3 with electronic handwheel.	SF 16	A speed monitoring in the safety function does not need to be considered. The normal functions (position controller or speed controller) are sufficient in combination with one of the listed initiating devices in PLr = d, Category 3.	Hazards exist for upper limbs	none, see remarks
			For rotational axes, the peripheral speed shall be considered at the maximum radius.	Hazard for the whole body	PLr = d Category 3
17.5	**Fluctuation or loss and return of power supply** initiated by interruption in MO 1, MO 2 or MO 3.	SF 17			PLr = a
17.6	**Safety-related stop function of machining process with interlocked guards being closed (normal stop)** initiated by the CNC/NC/PLC, e.g. collision control system.	SF 01	Group 3 and Group 4 machines	State of the art is PL = a	PLr = a
17.7	**Start and restart function to execute (e.g. of a program)** initiated by pressing Start button in MO 0.	SF 03	Group 1 and Group 2 machines		PLr = c
17.8	**Safety related stop function (normal stop)** initiated by pressing Stop button in MO 0.	SF 01	Group 1 and Group 2 machines		PLr = c

Table J.17 *(continued)*

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
17.9	**Safety-related stop function by releasing a direction control or hold-to-run control in conjunction with an enabling device** initiated when by pressed enabling device the direction or hold-to-run control released before the enabling device.	SF 01	Group 3 and Group 4 machines	State of the art is PL = a	PLr = a
17.10	**Manual reset function**	SF 02	After a stop command initiated by a safeguard, the stop condition shall be maintained until a proper condition for restart exists.	The re-establishment of the safety function by resetting of the safeguard cancels the stop command.	PLr = a
17.11	**Prevention of unintended movement of machine parts into an adjacent not authorized work zone**	SF 16	In pendular machine position of the machining part controlled by safety cams		PLr = d

Table J.18 — Hazardous movements in the work zone

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
18.1	**Safety-related stop function** initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3.	SF 01			PLr = c
18.2	**Safety-related stop function** initiated by release — of enabling device, — two-hand-control, or — hold-to-run control device in case of open interlocked guards or other protective devices in MO 2 or MO 3.	SF 07-1			PLr = c
18.3	**Prevention of unexpected start-up** initiated with non-actuated — enabling device, — two-hand-control, or — hold-to-run control device in case of open interlocked guards or other protective devices in MO 2 or MO 3.	SF 07-2		In case of short presence	PLr = c
					PLr = d, Category 3
18.4	Prevention of unexpected start-up initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3.	SF 08-1		In case of short presence	PLr = c
					PLr = d, Category 3

Table J.18 *(continued)*

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
18.5	**Safely limited speed (SLS) of linear, rotational and auxiliary axes** initiated by — in MO 2 or MO 3 with enabling device actuated, — in MO 2 or MO 3 with a hold-to-run control device actuated, — in MO 1, MO 2, MO 3 with two-hand control, or — in MO 2 or MO 3 with electronic handwheel.	SF 16	A speed monitoring in the safety function does not need to be considered. The normal functions (position controller or speed controller) are sufficient in combination with one of the listed initiating devices in PLr = d, Category 3	Hazards exist for upper limbs	None, see remarks
			For rotational axes, the peripheral speed has to be considered at the maximum radius.	Hazards exist for whole body	PLr = d Category 3

Table J.19 — Hazardous movements in the maintenance area

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
19.1	**Safety-related stop function** initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3.	SF 01	Also access to pits, doors within the perimeter fencing leading to maintenance areas only.		PLr = c
19.2	**Safety-related stop function** initiated by release — of enabling device, — two-hand-control, or — hold-to-run control device in case of open interlocked guards or other protective devices in MO 2 or MO 3.	SF 07-1	Also access to pits, doors within the perimeter fencing leading to maintenance areas only.		PLr = c
19.3	**Prevention of unexpected start-up** initiated with non-actuated — enabling device, — two-hand-control, or — hold-to-run control device in case of open interlocked guards or other protective devices in MO 2 or MO 3.	SF 07-2	Also access to pits, doors within the perimeter fencing leading to maintenance areas only.	In case of short presence	PLr = c
					PLr = d, Category 3
19.4	**Prevention of unexpected start-up** initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3.	SF 08-1	Also access to pits, doors within the perimeter fencing leading to maintenance areas only.	In case of short presence	PLr = c
					PLr = d, Category 3

Table J.19 *(continued)*

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
19.5	**Safely limited speed (SLS) of linear, rotational and auxiliary axes** initiated by — in MO 2 or MO 3 with enabling device actuated, — in MO 2 or MO 3 with a hold-to-run control device actuated, — in MO 1, MO 2, MO 3 with two-hand control, or — in MO 2 or MO 3 with electronic handwheel.	SF 16	A speed monitoring in the safety function does not need to be considered. The normal functions (position controller or speed controller) are sufficient in combination with one of the listed initiating devices in PLr = d, Category 3.	Hazards exists for upper limbs	None, see remarks
			For rotational axes, the peripheral speed has to be considered at the maximum radius.	Hazards exists for whole body	PLr = d, Category 3

Table J.20 — Safety interface for loading system — Automation safety features at the interface

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
20.1	**Safety-related stop function** initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3.	SF 01			PLr = c Category 3
20.2	**Prevention of unexpected start-up** initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3.	SF 08-1			PLr = d, Category 3
20.3	**Emergency stop input/output signals** Design Emergency stop according to the requirements of IEC 60204-1.	SF 14	The emergency stop function is an additional protective measure according to ISO 12100. The emergency stop acts independent of the mode of operation on all moving machine parts and mediums as safety-related stop function (SF 01 and SF 07-1).		PLr = c Category 3

Table J.21 — Grinding operation on a milling machine

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
21.1	**Limited spindle speed** initiated by safety related tool parameter in MO 1, MO 2 or MO 3.	SF 16	Limitation of grinding wheel peripheral speed with decreasing diameter. Safely limited peripheral speed of grinding wheel.		PLr = a

Table J.22 — Compressed air for cleaning and measuring processes

No.	Explanation of safety function effect, other requirements	No. of SF	Remarks	Additional explanation	PLr
22.1	**Safety-related stop function** initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3.	SF 01			PLr = a
22.2	**Safety-related stop function** initiated by release — of enabling device, — two-hand-control, or — hold-to-run control device in case of open interlocked guards or other protective devices in MO 2 or MO 3.	SF 07-1			PLr = a
22.3	**Prevention of unexpected start-up** initiated with non-actuated — enabling device, — two-hand-control, or — hold-to-run control device in case of open interlocked guards or other protective devices in MO 2 or MO 3.	SF 07-2			PLr = b
22.4	**Prevention of unexpected start-up** initiated by open interlocked guards or deactivated protective devices in MO 1, MO 2 or MO 3.	SF 08-1			PLr = b

J.5 Additional test of safety circuits with PL = d, Category 3

A functional test (automatic or manual) to detect failures shall be performed at least every 12 months.

It is recommended that the functional test is initiated by the control system of the machine. If this is not possible, then it is recommended that the control system of the machine reminds the user (e.g. by an appropriate indication at the control panel) to perform a functional test of the safety function. If this is also not possible, an appropriate requirement shall be contained in the instructions for use.

NOTE For test interval requirements regarding brakes or safe clamping devices of gravity loaded axes, see G.3.

Annex K
(normative)

Noise emission measurement

K.1 Operating conditions for Group 1, Group 2 and Group 3 machines

Noise emission within these groups of machines depends on many parameters, such as employed tool (e.g. hobbing cutter, milling cutter, replaceable cutting insert, drill, boring bar, etc.), sharpness of employed tool, cutting speed, employed lubricant as well as the workpiece itself and the mounting of it. Workpieces, which are processed on these groups of machines differ in their geometrical dimensions, shape (e.g. hollow vs. full, thin-walled) and material (e.g. aluminium, different kind of steel, cast). However, it is a typical characteristic of these groups of machines not to be single-purposed but to offer a maximum of flexibility in working a wide variety of workpieces. For that reason, it is not possible to define a typical workpiece. Due to this wide variety of influencing factors (tool, workpiece, machine), it is not possible to describe typical usage and operating conditions that would allow measurement results to be compared. In order to make noise emission measurement results comparable, the following operating conditions shall apply:

— idle running at 80 % of spindle maximum rotational speed;

— workpiece transfer operating (where applicable);

— tool changing and axes operating;

— swarf/chip conveyor running (if provided).

Noise emission levels determined according to the above operating conditions are likely to underestimate the noise emitted in real operation of the machine i.e. with a workpiece. It is recommended that the noise declaration given in the instructions for use gives a warning to this effect. Furthermore, from the experience they have with the noise emission in real operating conditions, manufacturers are recommended to provide users with quantitative information about the noise emission levels that the user can expect in real operating conditions, e.g. in terms of the difference between noise emission levels in real operation and those obtained according to this annex.

Mounting and operating conditions of the machine shall be in accordance to the manufacturer's instructions and be identical for the determination of emission sound pressure level at the workstation and the sound power level.

K.2 Operating conditions of Group 4 machines (transfer machines)

Noise measurements shall be taken under both of the operating conditions set out below.

a) Continuous automatic cycle production:

   — machine is running in continuous automatic cycle;

   — machine is running at full production rate;

   — all safeguards are in place;

   — any swarf/chip conveyors are running;

   — all machine services such as metalworking fluids are running;

   — all tooling is in place;

— machine running with full complement of workpieces and performing the designated process at each station.;

— where a machine is capable of processing more than one type of workpiece, then testing shall be performed to identify any significant difference between the measurements for the various workpieces and associated processes.

b) Automatic cycle without workpiece(s): Operating conditions shall be as identified in continuous automatic cycle above but without the workpiece. If the machine is a palletised machine the pallets shall be included but without workpiece.

Noise emission values determined for these operating conditions shall be declared.

K.3 Measurement procedure (for all groups of machines)

The A-weighted emission sound pressure level at the workstation shall be measured in accordance with ISO 11202:2010, but with the following modifications:

— the environmental indicator, K_{2A}, or the local environmental factor, K_{3A}, shall be equal to or less than 4 dB;

— the difference between the A-weighted background emission sound pressure level and the A-weighted workstation sound pressure level shall be equal to or greater than 6 dB;

— the local environmental correction, K_{3A}, shall be calculated in accordance with ISO 11204:2010, A.2, with the reference restricted to ISO 3746 instead of the method given in ISO 11202:2010, Annex A, or in accordance with ISO 3744:2010, where one of these standards has been used as the measuring method.

The A-weighted sound power level shall be measured in accordance with the enveloping surface measuring method shown in ISO 3746:2010, but with the following modifications:

— the environmental indicator, K_{2A}, shall be equal to or less than 4 dB;

— the difference between the A-weighted background sound pressure level and the A-weighted machine sound pressure level at each measuring point shall be equal to or greater than 6 dB. The correction formula for this difference (see ISO 3746:2010, 8.3.3) shall apply to a difference of up to 10 dB;

— only the parallelepiped measurement surface shall be used at 1,0 m from the reference surface;

— where the distance from the machine to an auxiliary unit is less than 2,0 m, the auxiliary unit shall be included in the reference box if it is an integral part of the machine;

— the measuring time required in ISO 3746:2010, 8.3, referring to 10 s shall be excluded;

— the accuracy of the test shall be better than 3 dB.

The number of microphones and their positioning shall be in accordance with ISO 3746. For the purpose of noise emission measurement, a machine can be considered as very large when at least one dimension of it exceeds 5 m. Consequently, for such machines, instead of measuring the A-weighted sound power level, A-weighted emission sound pressure levels at points equally spaced on a path around the machine at 1 m from the machine surface and 1,6 m above the floor or platform may be measured.

Alternatively, where the facilities exist, and the measuring method applies to the machine type, emission sound power levels may also be measured according to a method with higher precision (i.e. ISO 3744:2010 without the preceding modifications).

For determination of emission sound power levels by the sound intensity method, use ISO 9614-2.

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